



Installation and testing of hydraulic and electro-hydraulic controls

MD 07

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Training module:
Installation and testing of hydraulic and electro-hydraulic controls

Code of Module: MD07

Time: 120h.

(Theory: 40h; Practice: 80h)

I. Position and characteristics of the module

- This module is built up from single projects (exercises), each of them developing and implementing a hydraulic or electro-hydraulic system or subsystem.
- Every project is action orientated and carried out in such a way, that the trainee will be qualified for independent planning, conduction and checking of his work.
- Every project is standing alone and contains as many objectives as possible but only a limited number of contents.
- Starting with a real application the trainee has to analyze the process, design the documentation and circuit diagrams, to mount and install the system, commission the system and do the trouble-shooting. In this context the use and mounting of industrial components as well as the professional connection and installation of tubes and hoses are from special importance.
- Before this module is implemented, the trainee should have basic skills in mechanical engineering, special in assembling technology.

II. Objectives of the module

After finishing this module, the trainees are able to;

- Develop the scheme of hydraulic and electro-hydraulic controls in principle.
- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Follow and develop hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic and electric components in hydraulic and electro-hydraulic controls.
- Measure, check and calculate hydraulic parameters.
- Read and draw up circuit diagrams for hydraulic and electro-hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic and electro-hydraulic controls, commission and operate hydraulic systems and check the function.

- Determine the work steps required for carrying out the industrial mounting and installation of hydraulic controls.
- Read components-lists, assign designations to components and select components from catalogues.
- Mount hydraulic components in industry related manner, especially valves on base plates or modular blocks.
- Determine couplings and connectors for pipes and hoses under consideration of construction types, pressure level and threads.
- Produce pipelines by bending and mount to connectors by progressive ring (or similar)connection.
- Describe properties of hydraulic fluids and select suitable hydraulic fluids according to given applications.
- Carry out systematic maintenance, trouble-shooting and repair in hydraulic and electro-hydraulic controls,
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

III. Contents of the module

1. Content overview and time allocation:

No.	Name of lesson in the module	Duration			
		Sum	Theory	Practice	Tests
1	Design and installation of basic hydraulic systems	32	16	12	4
2	Design and installation of hydraulic systems for special applications	16	6	10	0
3	Industrial assembling and commissioning of hydraulic systems	32	8	20	4
4	Maintenance and trouble-shooting in hydraulic systems	10	2	8	0
5	Installation and testing of electro-hydraulic controls	22	8	14	0
6	Final examination with electro-hydraulic controls	8 *			8

* including preparation and evaluation

2. Detailed contents:

Lesson 1: Design and installation of basic hydraulic systems

(32h)

Objectives:

After finishing this lesson, the trainees are able to;

- Develop the scheme of hydraulic and electro-hydraulic controls in principle.
- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Follow and develop hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic components in hydraulic controls.
- Measure, check and calculate pressure, force, volume flow and speed in hydraulic controls.
- Read and draw up circuit diagrams for hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic controls, commission and operate hydraulic systems and check the function.
- Describe properties of hydraulic fluids and select suitable hydraulic fluids according to given applications.
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:

- 1.1 Structure and special features of hydraulic systems
- 1.2 Hydraulic power unit
- 1.3 Characteristic of gear pump
- 1.4 Measurement instruments in hydraulics
- 1.5 Control of lifting device with cylinder
- 1.6 Pressure limitation in hydraulic systems
- 1.7 Adjustment of system pressure
- 1.8 Lifting of load with middle position
- 1.9 Holding load in middle position
- 1.10 Adjustment of cylinder speed
- 1.11 Control of cylinder with varying load

- 1.12 Cylinder with fast forward stroke
- 1.13 Intermediate test 1

Lesson 2:

Design and installation of hydraulic systems for special applications (16h)

Objectives:

After finishing this lesson, the trainees are able to;

- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Follow and develop hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic components in hydraulic controls.
- Measure, check and calculate pressure, force, volume flow and speed in hydraulic controls.
- Read and draw up circuit diagrams for hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic controls, commission and operate hydraulic systems and check the function.
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:

- 2.1 Types and construction of hydraulic pumps
- 2.2 Hydraulic system with pressure limitation
- 2.3 Hydraulic systems with hydraulic motors
- 2.4 Hydraulic system with accumulator
- 2.5 Sequence control with 2 cylinders

Lesson 3:

Industrial assembling and commissioning of hydraulic systems (32h)

Objectives:

After finishing this lesson, the trainees are able to;

- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.

- Read and draw up circuit diagrams for hydraulic and electro-hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic and electro-hydraulic controls, commission and operate hydraulic systems and check the function.
- Determine the work steps required for carrying out the industrial mounting and installation of hydraulic controls.
- Read components-lists, assign designations to components and select components from catalogues.
- Mount hydraulic components in industry related manner, especially valves on base plates or modular blocks.
- Determine couplings and connectors for pipes and hoses under consideration of construction types, pressure level and threads.
- Produce pipelines by bending and mount to connectors by progressive ring (or similar) connection.
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)

Content:

- 3.1 Analyzing hydraulic lifting device
- 3.2 Selection and mounting of cylinders
- 3.3 Selection and mounting of valves
- 3.4 Selection and mounting of fittings
- 3.5 Manufacturing of tubes
- 3.6 Installation of tubes and hoses
- 3.7 Commissioning of lifting device
- 3.8 Installation of control with hydraulic motor
- 3.9 Hydraulic circuit with vertical modular block
- 3.10 Dismantling and mounting of power unit
- 3.11 Dismantling and mounting of cylinders and pumps
- 3.12 Intermediate test 2

Lesson 4:

Maintenance and trouble-shooting in hydraulic systems

(10h)

Objectives:

After finishing this lesson, the trainees are able to;

- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.

- Measure and check hydraulic parameters.
- Read hydraulic circuit diagrams and component lists with usage of industrial components.
- Determine the work steps required for carrying out inspection- and maintenance plans.
- Describe properties of hydraulic fluids and select suitable hydraulic fluids according to given applications.
- Carry out systematic maintenance, trouble-shooting and repair in hydraulic controls,
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:

- 4.1 Inspection and service
- 4.2 Hydraulic fluids
- 4.3 Trouble shooting in hydraulic controls.

Lesson 5:**Installation and testing of electro -hydraulic controls**

(22h)

Objectives:

After finishing this lesson, the trainees are able to;

- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Follow and develop electro-hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic and electric components in electro-hydraulic controls.
- Measure and check electric parameters.
- Read and draw up circuit diagrams for electro-hydraulic controls.
- Select electric components according to specifications and characteristics.
- Install electro-hydraulic controls, commission, operate and check the function.
- Carry out systematic trouble-shooting in electro-hydraulic controls,
- Describe and follow regulations for safety , particularly those arising from electric power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:

- 5.1 Lifting device, operated with 4/2-solenoid valve.

- 5.2 Lifting device with mid- position
- 5.3 Bending station – self locking control
- 5.4 Press fitting device – pressure control
- 5.5 Machining unit – sensing positions
- 5.6 Rapid-traverse feed circuit
- 5.7 Assembly device – sequence control

Lesson 6:**Final examination hydraulic and electro-hydraulic controls**

(8h)

Objectives:

After finishing this lesson, the trainees are able to;

- develop the scheme of hydraulic and electro-hydraulic controls in principle.
- read and apply technical documentations of hydraulic components and circuits.
- Follow and develop hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic and electric components in hydraulic and electro-hydraulic controls.
- Measure, check and calculate hydraulic parameters.
- Read and draw up circuit diagrams for hydraulic and electro-hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic and electro-hydraulic controls, commission and operate hydraulic systems and check the function.
- Determine the work steps required for carrying out the industrial mounting and installation of hydraulic controls.
- Read components-lists, assign designations to components and select components from catalogues.
- Mount hydraulic components in industry related manner, especially valves on base plates or modular blocks.
- Determine couplings and connectors for pipes and hoses under consideration of construction types, pressure level and threads.
- Produce pipelines by bending and mount to connectors by progressive ring (or similar)connection.
- Describe properties of hydraulic fluids and select suitable hydraulic fluids according to given applications.
- Carry out systematic maintenance, trouble-shooting and repair in hydraulic and electro-hydraulic controls,
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.

- Communicate with partners (customers, suppliers and colleagues)

Content:

- 6.1 Theoretical examination.
- 6.2 Practical examination training station
- 5.3 Practical examination industrial assembling

IV. Prerequisites for implementation of module

- **Hydraulic Lab:**

- Size of room: min. 80m²
- For 12 to 16 trainees
- Training stations: max. 3 students at each training station (4 to 5 stations)
- Assembling stations: max. 2 students at each assembling station (6 to 8 stations)
- Work-benches with vice (6 to 8)
- Power supply in cable duct round the lab.
- For every station 2x230V, 1 3-phase socket, 1 network socket
- Control cabinet with fuses and emergency switch off
- Working place for teacher with PC and printer
- Blackboard, magnetic, min 2,5 x 1,2m
- Overheadprojektor, Beamer and projection screen
- Chairs and tables for theory and practice
- Storage cabinets for teaching aids and equipment.

- **Training stations (for 4 to 6 students):**

- Moveable working station with two vertical or inclined profile plates for two-sided use
- Oilpan
- 2 drawer units with 3 drawers for components
- Mounting frame for electric components
- Hose holder
- Hydraulic power unit with two pumps
 - 3-phase current, 400V, min. 1 kW
 - capacity: min 40l
 - delivery rate: min: 2 x 3.8l/min
 - pressure: min 60 bar, recommended 120 bar

- **Equipment set basic hydraulics (for 2 to 3 students)**
 - Pressure gauges
 - Flow control valve
 - One-way flow control valve
 - Shut-off valve
 - Non-return valve
 - T-connectors
 - Pressure relief valve
 - 3-way pressure reducing valve
 - 2-way flow control valve
 - Non-return valve delockable
 - Double acting cylinder
 - Hydraulic motor
 - Diaphragm accumulator with shut-off block
 - Weight with guidance and cover
 - 4/2 hand lever valve
 - 4/3 hand lever valve with recirculating mid-position
 - set of hose lines

- **Measuring equipment set** (for 2 to 3 students)
 - Digital indication (display)
 - Flow measurement device
 - Pressure sensor
 - Temperature sensor

- **Equipment set advanced hydraulics** (for 2 to 3 students)
 - Double acting cylinder, differential cylinder
 - One way flow control valve
 - Pressure relief valve
 - Flow dividing valve
 - 4/3 hand lever valve, closed mid position
 - 4/3 hand lever valve, relieving mid position

- **Upgrading equipment set from hydraulics to electro-hydraulics** (for 2 to 3 students)
 - Electric power supply for mounting frame
 - Relay, 3-fold

- Signal input, electrical
- Indicator unit and distributor, electrical
- 4/2-way-solenoid valve
- 4/3 – way solenoid valve
- limit switch electrical
- inductive sensor
- Set of industrial pneumatic components for assembling

- **Assembling stations hydraulic for industrial assembling** (for 2 students)
 - Moveable working station with 1 vertical installation panel
 - Cylinder, pre-assembled
 - 4 base plates pre-assembled
 - ports for pressure and return line to be connected to hydraulic power unit

- **Set of industrial components for hydraulic assembling on base plates** (for 2 students)
 - 4/3- hand lever valve
 - Pressure relief valve
 - Check valve, delockable
 - One-way flow control valve
 - Assortment of fittings
 - Tubes
 - Modular vertical block

- **Working bench with vice** (for 2 students)

- **Tool set for assembling** (for 2 students)
 - Spanners, allen keys
 - Torque wrench
 - Tube bending device
 - Tube cutting tool
 - Deburring tool
 - Hacksaw, files
 - Measuring instruments

- **Teaching media**
 - Set of magnetic symbols hydraulic

- Set of magnetic symbols electric
- Software for design of circuits, demonstration of function of components
- Section-models of components

V. Evaluation methods and contents of tests

- The evaluation of this modules contains:

1. Intermediate test 1

1.1 Written examination hydraulic controls

The trainee solves in max. 90min questions and exercises, multiple choice or essay questions, related to objectives and contents of the lesson “Design and installation of basic hydraulic systems”.

1.2 Practical test hydraulic controls

The trainee installs in max 60min a hydraulic control according to given documentation at the hydraulic training station and commissions this control.

2. Intermediate test 2

2.1 Written examination industrial assembling

The trainee solves in max. 60 min questions and exercises, multiple choice or essay questions, related to objectives and contents of the lesson “Industrial assembling and commissioning of hydraulic systems”.

2.2 Practical test industrial assembling

The trainee manufactures in max 120 min one or more tubes and connects tubes and hoses in industrial manner with selected fittings to assembling station, commissions the system and check via pressure trial for leakage.

3. Final examination with electro-hydraulic controls

3.1 Written examination theory

The trainee solves in max. 120min questions and exercises, related to objectives and contents of this module, under special observance of electro-hydraulic controls.

3.2 Examination work piece

The trainee installs in max 120min an electro-hydraulic control with industrial components at the training station according to given documentation and commissions this control.

VI. Guide for implementation of the module

- **Fields of implementation of this module:**

- This module is used to qualify the trainees of vocational training programme at 2-year intermediate level for mechatronic trade on the level of skilled worker.

- This module is a basic module, that could be also used to train:
 - mechatronic trade on college level
 - mechatronics at university level
 - trades in the field of mechanical engineering
- Trades in the field of automotive, specialized in heavy trucks and building and construction machinery
- **Organization:**
 - The lessons of this module should be organized in large blocks of at least one week up to 4 weeks duration to guarantee a steady work, especially in the practical parts. It is not practicable to interrupt the work of the students and use the components for assembling and installation for another group of students.
- **Some main guides in view of teaching methods for this module:**
 - Before implementation of this module, the teaching staff should prepare all necessary prerequisites based on contents of individual lessons to ensure the teaching quality.
 - The teaching staff should guide the students to the ability to plan, execute and monitor their work independently.
 - The teaching staff should guide the students to independent problem solving.
 - All exercises should be focused on real situations, as they could take place in hydraulic application.
 - The teaching staff should instruct, give examples and correct errors while the trainees practice.
 - The teaching staff should use real industrial components and applications to implement the exercises.
 - From special importance are safety regulations and measures for environmental protection. Oil should never come in contact with soil. There must be precautions to absorb leakage oil and dispose according to regulations.
 - Students should wear protective clothes while working with hydraulic systems.
 - As the industrial bending of tubes and their assembling needs a lot of experience, the teachers or trainers have to test and upgrade their skills before starting the training in lesson 3.
- **Reference documents**
 - Teaching and learning materials for module 07 " Installation and testing of pneumatic and electro-pneumatic controls", published by GTZ, TVET Vietnam (if available)
 - Bosch AT-didactic: "Hydraulics, theory and applications" ISBN 3-9805925-3-7
 - Bosch AT-didactic: "Bosch Practice for professionals" ISBN 3-933698-06-5

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- Bosch Rexroth AG “BIBB Hydraulics, Basics” Order No. R900071655
 - Bosch Rexroth AG “BIBB Electro-hydraulics” Order No. R900071655
 - Bosch Rexroth AG „ The Hydraulic Trainer“ Order No. R 900018614
 - FESTO DIDACTIC “Hydraulics, Basic level, textbook” Order No. 093 281
 - FESTO DIDACTIC “Hydraulics, Basic level, workbook” Order No.094468
 - FESTO DIDACTIC “Hydraulics, advanced level, workbook” Order No. 094015
 - FESTO DIDACTIC “Electro-hydraulics, basic level, textbook” Order No. 093611
 - FESTO DIDACTIC “Electro-hydraulics, basic level, workbook”Order No. 094470

Assembling station



Training station



There is only one hydraulic power unit necessary for both stations.

Special features:	Special features:
<ul style="list-style-type: none"> The assembling station could be build locally. 	<ul style="list-style-type: none"> The training station is designed from didactic-providers
<ul style="list-style-type: none"> The trolley could be assembled from profiles or welded from square tubes. 	<ul style="list-style-type: none">
<ul style="list-style-type: none"> There is no profile plate but a sheet metal plate 	<ul style="list-style-type: none"> The components are fixed on profile plates
<ul style="list-style-type: none"> The standard industrial cylinder is mounted 	<ul style="list-style-type: none"> All components are connected with hoses
<ul style="list-style-type: none"> At least 4 base plates are mounted 	<ul style="list-style-type: none"> The valves are fixed to base plates, no mounting on backside
<ul style="list-style-type: none"> The valves are to be mounted by the students on the base plates 	<ul style="list-style-type: none"> Hoses and components are equipped with quick couplings, not industrial standard.
<ul style="list-style-type: none"> All tubes are connected at the backside of the base plate, as it is common in industry. 	<ul style="list-style-type: none">
<ul style="list-style-type: none"> leakage oil during assembling and 	<ul style="list-style-type: none"> very little leakage oil

dismantling	
<ul style="list-style-type: none">• Not recommended for experimental circuits because of the leakage.	<ul style="list-style-type: none">• Not possible for industrial assembling because backside of base plate is covered from profile plate.
Both systems are complementing each other. It is not possible to replace one system by the other.	

