# Procedures for Competence-Establishment in the EDGE Project – Template for In-Company Trials

## Results of the Working Groups Held on 23.02.2011 and 24.03.2011 in Esslingen

The document first names the learning units which were selected for the two professions: “electronics engineer for automation technology” and “mechatronics engineer”. The learning-result-oriented description of the learning units stands at the beginning of the document and serves as a basis for the description of typical work-actions in terms of real work- and business-processes. The typical work-actions are described in terms of the phases of the “self-contained activity”. Finally, evaluation tools are assigned to these phases.

## Document Structure

## 1. Basic Data: Profession Being Trained For, Learning Unit, Learning Result

| **Profession being trained for** | **Electronics engineer for automation technology** |
|---|---|
| Learning unit | Learning unit 6 |
| Title of learning unit | Construction and Commissioning of Programmable Logic Controllers (PLCs) |
| Duration of learning unit | 5 months |
| Training year | 1 and 2 |

| ***Learning Unit*** | ***No. 6*** | **Construction and Commissioning of Programmable Logic Controllers (PLCs)** |
|---|---|---|
| ***Knowledge and Know-How Content*** | | |
| The trainees are able to explain the bases, and the basic circuitry, of digital technology, and can name the circuitry structures and the components, along with the sources of malfunctions and the ways of eliminating malfunctions. They can explain the processes involved in the control systems and in the programming of Programmable Logic Controllers (PLCs), understand how these programmes are installed and utilized, and can clarify and interpret this to others. They can explain simple programming procedures and programming languages. They can name different forms of hardware and software and can distinguish between the different possibilities and preconditions of these latter's use.<br>The trainees are able to explain the structure and the manner of functioning of networks and bus systems, can cite the participants in these latter and their deployment, and can identify the causes of malfunctions and recommend solutions.<br>They are able to explain the sequence of work-processes involved in the construction and the commissioning of Programmable Logic Controllers (PLCs), describe sources of malfunctions and explain ways of dealing with said malfunctions.<br>The trainees are able to list appropriate hardware and to describe the different possible ways of deploying and utilizing it.<br>They are able to give clear explanations of the different types, and different ways of functioning, of sensors and actuators.<br>The trainees are able to read and interpret programme documentation, assignment lists, and symbol lists. | | |

| ***Skills*** |
| --- |
| The trainees themselves prepare the operational and work-materials necessary for their own work-task. They take work instructions from technical documentation. They draw up circuit diagrams.<br>The trainees write simple computer programmes, possess a mastery of various programming languages used in the field of Programmable Logic Controllers, are able to check and test the preconditions for the installation and use of various items of hardware and software, and can configure, install, and adapt these latter. They are able themselves to correct any such errors or malfunctions as may arise.<br>They are able to construct basic circuitry in the area of digital technology, to seek out errors and malfunctions, and to deal with these.<br>They construct Programmable Logic Controllers, hardwire them, assemble various system components such as sensors and actuators, and connect them.<br>The trainees are able to themselves draw up programme documentation, assignment lists and symbol lists. Thanks to their knowing the basic functions of bus systems the trainees are also able to integrate other participants, to identify sources of error and malfunction, and to deal with and eliminate these latter. They install and configure networks and bus systems, check signals at interfaces, and deal with errors and malfunctions.<br>They programme the basic functions of Programmable Logic Controllers onto hardware and software specific to the enterprises they work for, and apply these in systems. |
| ***Competence*** |
| The trainees can give an account of the fundaments of digital technology. They can, without help, carry out all the necessary steps required to construct Programmable Logic Controllers. They use various programming languages and programming procedures, utilize various types of software, and are able themselves to judge which hardware they need to select in which situation. They can commission a Programmable Logic Controller without assistance from any-one else and are able to deal alone with any errors or malfunctions that may arise. In their work, the trainees respect safety and environmental-protection guidelines reliably and without needing to be prompted by others. |

| Profession being trained for | Mechatronics engineer |
|---|---|
| Learning unit | Learning unit 7 |
| Title of learning unit | Construction and Commissioning of Programmable Logic Controllers (PLCs) |
| Duration of learning unit | 3 months |
| Training year | 1 |

| *Learning Unit* | *No. 7* | **Construction and Commissioning of Programmable Logic Controllers (PLCs) and of Simple Control Systems** |
|---|---|---|

***Knowledge and Know-How Content***

The trainees are able to explain the control-system and programme sequence of Programmable Logic Controllers (PLCs), understand how the programmes are applied, and can elucidate the contexts and connections. They have mastered simple programming procedures, are able to name various types of hardware and software, and can explain the possibilities and preconditions of the application of these latter.

The trainees can explain the structure and the manner of functioning of networks and bus systems (in the 3rd academic year of the trade school / *Berufsschule*), can adduce the participants in such networks / systems and the manner of their deployment, and can state the causes of errors / malfunctions and the solutions appropriate to same.

They are able to explain the sequence of work-processes necessary to the construction and the commissioning of Programmable Logic Controllers, outline the sources of error and malfunction, and explain ways of dealing with and eliminating same.

They are able to read and interpret programme documentation, assignment lists, and symbol lists. The trainees are able to put into operation, and to adjust, control systems involving basic control mechanisms.

***Skills***

The trainees themselves prepare the operational and work-materials necessary for their own work-task. They take work instructions from various forms of technical documentation. They draw up circuit diagrams.

The trainees write simple programmes, test and check the prerequisites necessary for the de-

ployment of various different forms of hardware and software, and configure, install and adjust said hardware and software.

They construct Programmable Logic Controllers, assemble various system components, and connect them.

The trainees are able to draw up programme documentation, assignment lists, and symbol lists.

Thanks to their knowing the basic functions of bus systems the trainees are also able to integrate other participants, to identify sources of error and malfunction, and to deal with and eliminate these latter. They install and configure networks and bus systems (in the 3rd academic year of the trade school / *Berufsschule*) check signals at interfaces, and deal with errors and malfunctions. When doing this, they utilize, under their own supervision, the appropriate checking and measuring tools and instruments.

They are able to programme the basic functions of Programmable Logic Controllers onto hardware and software specific to the enterprises they work for, and to apply these basic functions in mechatronic systems.

***Competence***

The trainees are able, without help, to carry out all the necessary steps required to construct Programmable Logic Controllers. They are able to apply the basic functions of these latter on their own initiative and are able themselves to judge which hardware they need to select in which situation. They do not require help in commissioning the Controllers and in putting them into operation, nor in dealing with errors and malfunctions.

## 2. Description of a Typical Work-Action

Basis: “Self-Contained Activity”

**Example of a work-task: “Conversion of a hard-wired programmable logic controller into a programmable logic controller, with commissioning of same (incl. documentation)”**

An examination establishing qualification as a skilled electronic technician must already have been passed, or knowledge in this field must already have been confirmed, before the task is accepted, thus complying with Federal German Accident Prevention Regulations (regulations of the Employer’s Liability Insurance Association A3, Technical Rules for Workplace Safety 2131 and 1201, and DIN VDE 0105 Part 100 and DIN VDE 1000 Part 1)

| **Phase**<br>*Proportion of total time spent on phase (“time-weighting”)* | **Contents** | **Evaluation Elements**<br>*Time-weighting as benchmarks* |
|---|---|---|
| 1) Informing<br>*10%* | Re-working of incomplete pneumatics plan<br>Drawing-up of circuit diagram for hard-wired programmable logic controller | Setting of written task, related to information and planning phase of the respective work-task: **20%**<br><br>Work-plan**: 10%** |
| 2) Planning / Decision<br>*20%* | Planning of the execution (calculation of time needed, possibly calculation of costs), inc. operational and work-materials | |
| 3) Execution<br>*50%* | Wiring and programming of the program-mable logic controller<br>Documentation with the paperwork usual within the enterprise | Test report, and testing of the test report by random sampling: **30%**<br><br>Functional testing: **20%** |
| 4) Quality assurance<br>*15%* | Checking of actual and ideal values<br>Commissioning<br>Contributing to Continual Improvement Process in this work-area | |
| 5) Delivery<br>*5%* | Delivery to the customer | Delivery interview (specialized discussion of 5 – 10 minutes): **20%** |

The total duration of the entire action should – with adaptation in each case here to the respective individual learning unit – amount, at the least, to 180, and, at the most, to 420 minutes (corresponds to 3 to 7 hours). These figures represent benchmark figures. Their relative importance within the "self-contained activity" may vary depending upon the particular enterprise concerned. The individual phases of the "self-contained activity" are likewise variable in duration. The temporal benchmarks for the individual phases serve only the purpose of orientation.

In the very centre of competence-establishment stands a practical work-task (work-process). This practical work-task is oriented in its sequence of phases to the principle of the "self-contained activity". This "self-contained activity" demands, or comprises, all the relevant professional action-competences of the respective learning-unit (e.g. planning-related competences with specialized knowledge and craftsmanship-related competences in the process of execution.)

## 3. Evaluation Tools

- **Setting of Written Task** during the information and planning phase (tasks: e.g. description of the criteria for the use of programmable logic controllers and execution of a use-of-potential analysis): taking into account of minimum standards (e.g. the standards set for such task-setting by the Test Task and Teaching Material Development Office (*Prüfungsaufgaben- und Lehrmittelentwicklungstelle*) of the German Chambers of Commerce and Industry), consisting of short-answer tests, embedded and / or non-embedded questions. The vocational school / *Berufsschule* should be involved in the drawing-up of the questions and in the correction process.

- **Practical Work-Task**: Functional test (OK / not OK), test report (to be drawn up by tested individual themselves), testing of test report by random-sampling method.

- **Documentation** using the paperwork usual in the enterprise (work-plan, test reports, drawing documentation)

- **Specialized Interview** in the form of a "delivery interview" (at least 5 minutes)

- **Outside of the Evaluation**: Assessment forms for social and personal competences (especially for taking on of responsibility, and for self-reliance).