

**Making Permanent Joints – Course: Basic Skills and Knowledge of
Electrical Engineering. Methodical Guide for Instructors**

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Institut für berufliche Entwicklung e.V.
Berlin

Original title:

Methodische Anleitung für den Lehrenden
"Herstellen von unlösbaren Verbindungen"

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First Edition © IBE

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Parkstraße 23
13187 Berlin

Order No.: 91–32–3103/2

1. Aims and Contents of Practical Vocational Training in the Working Techniques of "Making Permanent Joints"

After having finished their training based on this lesson, the trainees shall have achieved the following aims:

- They have the necessary knowledge and skills for making permanent joints.
- They can work with manufacturing documents, engineering drawings and working drawings.
- They are able to do the work in the quality required.
- They meet the safety requirements.

In order to achieve the above aims, the following knowledge and skills must be taught by the instructor:

Knowledge

- Design, operation and applications of the tools.
- Steps of work required for making permanent joints.
- Quality requirements for permanent joints.
- Labour safety requirements.

Skills

- Handling of tools.
- Maintenance and servicing of tools.
- Making soldering joints.
- Making notched joints.
- Making pressed joints.

2. Organizational Preparation

In order to ensure that the instructions, demonstrations and exercises go off smoothly, the training must be well prepared.

This includes:

2.1. Preparation of Labour Safety Instructions

Prior to the exercises the trainees must be instructed in brief on how to properly handle the working tools and prevent accidents.

It is recommended to prepare a book in evidence of the labour safety instructions given to note down in brief outlines all instructions given for preventing accidents and for handling the working tools properly. The trainees should then confirm by their signature that they have been instructed accordingly.

The instructions should include the following:

- Tools must be in proper condition.
- Cords and plugs of electric appliances must not be damaged.
- When leaving the room, electric appliances are to be switched off or disconnected from the power supply.
- Electric appliances must never be unattended.
- Electric soldering devices must be secured from falling down.
- Electric soldering devices are to be stored on non-inflammable supports.
- Damaged bits of soldering devices must be removed for repair.
- Tin baths should be centrally located in the room.
- Fluids must not be poured into tin baths because of the danger of explosion-like splashing of the fluid soldering tin and of the fluid.
- Soldering fluxes have caustic constituents and must not get into contact with skin. Fumes generated during soldering must not be breathed in directly.
- In case of comprehensive soldering work, fume extraction is to be provided or sufficient fresh air to be supplied.
- Inflammable fluids and gases are to be stored in prescribed containers.
- Inflammable fluids are to be stored at the place of work in small quantities only.
- Blowtorches are to be filled and put into operation outdoors.
- Blowtorches must cool down before filling.
- Adaptors of tools must not be changed unless the tools are out of operation.
- When working with rotating tools, closely fitting clothes are to be worn.
- Don't grip into pressing or notching adaptors when making the joints.
- Tools and materials are to be deposited clearly and neatly arranged.

Other labour safety instructions can be given for special local conditions.

2.2. Preparation of the Necessary Teaching Aids

- The theoretical instructions should be given at a place where the trainees are able to make notes, preferably a class-room with blackboard, desks and mains supply.

- When the instructions are given in the workshop at the workplace, the tables should be provided with clean supports for the papers etc. to be deposited.

For demonstrations during the instructions a workplace should be equipped as follows:

- For making soldered joints with conductor material: soldering device, cable eye, soldering tags, components and a printed circuit board.
- For making wire-wrap joints with conductor material: connecting element, tools for preparing the conductors, wrapping tool and testing tools.
- For making notched joints with conductor material: tools for preparing the conductors, notching tool, sleeves and cable eyes.
- For making pressed joints with conductor material: tools for preparing the conductors, pressing tools, cable eyes and sleeves.

Sufficient copies of the "Trainees' Handbook of Lessons – Making Permanent Joints" are to be made available to provide one copy to each trainee.

Tables etc. are to be written on the blackboard prior to the instructions.

All tools and accessories for making permanent joints as mentioned in section 3 are to be made available as visual aids.

2.3. Preparation of Working Tools and Materials

Sufficient copies of the "Instruction Examples for Practical Vocational Training – Making Permanent

Joints" are to be made available to provide one copy to each trainee as theoretical basis for the exercises to be done.

The initial materials necessary for the exercises as specified in the "Instruction Examples..." are to be prepared and kept ready in sufficient quantity.

Each trainee must have a workplace with a vice and mains supply connection.

The trainees' workplaces are to be checked for complete equipment with tools and accessories required for the planned exercises.

Recommended basic equipment:

- Screw drivers 2, 4, 6, 8, 10 mm
- Combination plier
- Flat nose plier
- Round nose plier
- Adjusting plier
- Side cutting plier
- Stripping plier
- Cable stripper
- Scraper
- Hand hacksaw with metal saw blade
- Wire brush
- Bastard file and smooth file 200 mm (half round)
- Hammer
- Soldering iron
- Soldering flux
- Spirit
- Folding rule
- Wrapping set

- Notching plier
- Pressing plier

2.4. Time Planning

Based on the total hours available, the times for the individual training sections of this lesson should be planned individually.

Time planning is recommended for the following sections:

- Introduction into the relevant working technique in the form of instructions including labour safety instructions.
- Necessary demonstrations.
- Job-related instructions to prepare the exercises.
- Exercises/practising.
- Recapitulations and tests.

In such time planning the following factors should also be taken into consideration:

- Level of training reached by the trainees,
- training conditions,
- future assignment of the trainees,
- level of difficulty of the relevant training section.

The emphasis in each training section should be on the acquisition of practical skills and abilities. Any waiting times occurring for the trainees in spite of good planning should be bridged by suitable preparatory work, such as preparation of conductor material.

3. Recommendations for Realizing Practical Vocational Training in the Working Techniques of "Making Permanent Joints"

The following sections contain recommendations on how to organize and implement the instructions, demonstrations of the working techniques as well as exercises and tests. The instructions for making the joints can be given regardless of the order specified.

3.1. The Introductory Instructions, Demonstrations and Exercises

The introductory instructions for each working technique can be given in a class-room. During the instructions the trainees should be advised to note down necessary additions or answers into the "Trainees' Handbook of Lessons".

The arrangement of the contents of the "Trainees' Handbook of Lessons" is adapted to the introductory instructions and the main points therein contained should be taught. The knowledge of the working techniques of treating cables and wires should be repeated and referred to since a good command of those working techniques is a pre-condition for acquiring the working techniques of "Making Permanent Joints". The subjects of "Types and Meaning of Permanent Joints" and "Tools for Making Permanent Joints" should be taught intensively using all teaching aids available.

Types and meaning of permanent joints

In order to make clear the types and meaning of permanent joints, it is recommended to show to the trainees finished joints made by welding, soldering or pressing, for example, for comparison. Such joints are then to be identified by means of the table in the "Trainees' Handbook of Lessons" and the possibilities of making and using them can be derived in a dialogue.

Tools for making permanent electrical joints

Original tools should be used to explain the basic design, operation, handling and requirements for use of the tools required for the relevant types of joints. The instructions should also contain recommendations for attendance, servicing and maintenance of the tools.

For testing the trainees' knowledge, the instructor should show tools and let the trainees repeat the designation of the parts of the tool, their functions and the mode of operation of the tools.

Then the trainees should note down in the "Trainees' Handbook of Lessons" which type of joint the relevant tools is used for. The notes are to be checked by having them read by one trainee while the other trainees are comparing and, if necessary, correcting their notes.

Making soldering joints

In this working technique the trainees shall acquire basic skills and abilities in soldering. The emphasis should be on the following main points:

- Correct preparation of the joint to be soldered.
- Proper use and handling of the soldering devices.
- Making a correct soldered joint.
- Meeting the labour safety requirements.

Before dealing with the actual sequence of operations, the trainees should be informed on the main metals that can be soldered, particularly in electrical engineering/electronics. It should be pointed out that copper can be easily soldered, but aluminium under certain conditions only.

In practice, there is a wide variety of forms of soldered joints. The preparation for soldering, however, is always the same. The following procedure is to be explained and demonstrated.

- Cutting to length and stripping of conductors.
- Cleaning of the soldering surfaces.
- Flux-treatment of the soldering surfaces.
- Tin-coating of the soldering surfaces.
- Making the soldered joint.
- Inspection of the soldered joint.

The demonstration of the steps of work involved is to be well prepared. To enable all trainees to see the demonstration, it is recommended to form groups of 6 to 8 trainees. The trainees of one group should be positioned around the place of demonstration so that they can easily watch the individual operations demonstrated. Then the instructor demonstrates how to make a soldered joint following the procedure given above. It is important

- that the instructor explains the purpose of his activities during the demonstration,
- that the trainees realize that making a soldered joint calls for great care, calmness and expertise,
- that the instructor's example is a decisive factor motivating the trainees in their work.

The demonstration may then be repeated by one trainee. The instructor must see to it that it is properly done and correct any mistakes immediately. Then the group is exchanged.

To bridge any waiting times, the trainees may answer the respective questions in the "Trainees' Handbook of Lessons" on their own. The answers are to be checked by the instructor. To develop the trainees' practical skills it is then necessary for the trainees to practise the making of soldered joints.

The exercises can be carried out on any conductor material available. The instructor should see to it that the level of difficulty of the exercises is adapted to the trainees' level of skills. It is recommended to have the exercises carried out in the following order:

- Tin-coating of different soldering surfaces.
- Joining of wires and wires.
- Joining of wires and cable eyes.
- Joining of wires and soldering tags.
- Joining of components and soldering tags.
- Joining of wires and components.
- Soldering on printed circuit boards.

The example from the "Instruction Examples for Practical Vocational Training" may also be used for practising. In this case it will be necessary to prepare and implement a "job-related instruction". For carrying out the work it is recommended to determine criteria for observation and evaluation, such as:

Cutting to length and stripping of conductors

- Did the trainee use the right tool?
- Is the stripped length in accordance with the relevant joint?
- Is the conductor undamaged?

Cleaning of the soldering surface

- Did the trainee use the right tool?
- Is the soldering surface metallic-bright?

Flux-treatment of the soldering surface

- Is the soldering surface completely moistened?

Tin-coating of the soldering surface

- Is the insulation of the conductor undamaged?
- Did the trainee use the right soldering tool?

Making the soldered joint

- Did the trainee use the right soldering tool?
- Did he use just as much soldering tin as necessary?

Inspection of the soldered joint

- Does the soldered joint meet the quality requirements?
- Is any insulation burnt?
- Are there any inclusions?
- Are any wire systems lifted off the printed circuit board?

Such criteria of evaluation should be made known to the trainees before they start with the exercises.

Making wire-wrap joints

In this working technique the trainees shall acquire basic knowledge and skills in making wire-wrap joints. The emphasis should be on the following main points:

- Preparation of the joint to be wrapped.
- Use and handling of the wrapping tools.
- Making the wire-wrap joint.
- Meeting the labour safety requirements.

Making a wire-wrap joint calls for much practice and manual skill. Therefore, great importance is to be attached to practising. At first, the instructor should explain the fundamentals, the advantages and

disadvantages of wire-wrap joints. This should also include explanations as to possible connecting forms of wrap pins and types of wire-wrap joints. After such introduction the steps of work are to be explained and demonstrated to the trainees. Knowledge already acquired should be questioned.

The trainees have to learn the following steps of work:

- Cutting to length and stripping of conductors.
- Feeding the wire into the wrapping mandrel.
- Making the wire-wrap joint.
- Inspection of the wire-wrap joint.

The demonstration of the individual steps of work is to be well prepared.

The demonstration should be implemented in groups like the demonstration of making soldered joints.

It is important:

- that all trainees can closely watch the demonstration,
- that the instructor explains all his activities,
- that the trainees realize that wire-wrap joints are to be made carefully and thoroughly,
- that the instructor's example is a decisive factor in motivating the trainees in their work.

After the demonstration of the steps of work it is recommended to have the steps repeated by the trainees so that their knowledge of the procedure of making wire-wrap joints will become more solid.

The instructor may also demonstrate the opening of a wire-wrap joint. It is to be pointed out that this also serves for testing the wrapping tools.

To bridge any waiting times, the trainees may, for example, prepare conductor material for wrapping exercises. Then the trainees can answer the questions in the "Trainees' Handbook of Lessons" on their own. The answer must be checked by the instructor.

In order to develop the trainees' practical skills, they have to practise the making of wire-wrap joints, and the exercises should be evaluated to the following criteria:

- Did the trainee use the right stripping tool?
- Does the conductor have any notches?
- Does the wire-wrap joint have a firm seat?
- Is the number of windings correct?
- Are all windings arranged one after the other?
- Is the direction of winding correct?

Making of notched joints

In this training section the trainees shall acquire the necessary knowledge and skills for making notched joints.

The emphasis should be on the following main points:

- Preparation of the notched joints.
- Use and handling of the notching tools.
- Making and inspection of the notched joints.

At first, the trainees should be made familiar with the application and advantages and disadvantages of notched joints. After such introduction the necessary steps of work are to be worked out with the trainees, such as:

- Cutting to length and stripping of the conductor.
- Cleaning of the conductor.
- Feeding the conductor into the cable eye or sleeve.
- Making the notched joint.
- Inspection of the notched joint.

After that the instructor should demonstrate how a notched joint is made. The demonstration should be carried out in the same way as for making soldered joints and wire-wrap joints.

After the demonstration the trainees can answer the respective questions in the "Trainees' Handbook of Lessons". The answers are to be checked by the instructor. To develop the trainees' practical skills, the trainees should practise the making of notched joints on various conductor cross-sections. But it is also possible to start immediately with the exercise suggested in the "Instruction Examples for Practical Vocational Training".

The following criteria of evaluation for the proper execution of a notched joint are to be announced to the trainees:

- Did the trainees use the right tool for the conductor?
- Does the cable eye or sleeve have a firm seat on the conductor?
- Does the distance between the insulation of the conductor and the neck of the cable eye have the required length?

Making pressed joints

In this working technique the trainees shall acquire the necessary knowledge and skills for making pressed joints. The points of emphasis in training, the steps of work for making pressed joints and the criteria for evaluation are similar to those for making notched joints.

Therefore, the trainees should repeat the technological sequence for making notched joints.

The instructor has to point out special features for making pressed joints and demonstrate the use of pressing tools. Practical skills already acquired are to be consolidated by further practising.

3.2. Recommendations for Working with the Instruction Examples for Practical Vocational Training

The "Instruction Examples" describe the sequence of operations and contain a working drawing for making permanent joints between a conductor and a cable eye by soldering, notching and pressing.

Moreover, the recommended materials, a list of the necessary working, measuring and testing tools as well as accessories are included for each example.

Depending on the application of the joint to be made, the length of the conductor material should be specified by the instructor in a brief instruction.

Thus the trainees have any information required for properly doing the exercises.

The following should be considered in the organization of the work:

The trainee should do himself any work involved in the instruction example, from preparing the initial material up to completion.

This is the only way of ensuring a just evaluation.

3.3. Examples for Recapitulation and Tests

This section contains questions to strengthen and test the knowledge and skills acquired. The answers to the questions are also given. Questions, which are also contained in the "Trainees' Handbook of Lessons", are marked with the letter "A".

1. What are permanent joints?

(Joints which can be detached only by destroying the connecting elements.)

2. Which tools are required for making a) material-closed joints, b) force-closed joints, c) form-closed joints?

"A" (a) soldering devices; b) notching and pressing tools; c) wrapping tools;)

3. Which tools are required for stripping various conductor diameters or cross-sections?

"A" (single-wire conductor 0.45... 0.8 mm² scraper
single-wire conductor 1 mm²
single-wire conductor 1.5... 6 mm² stripping plier
single-wire conductor exceeding 6 mm² cable stripper
wire and tinsel conductors flame cleaner)

4. Why must soldering surfaces be treated with flux prior to soldering?

"A" (Removal of unwanted layers from the conductor surface and protection of the conductor, facilitates flowing of the solder.)

5. What steps are required for joining a component and soldering tag?

"A" (Feeding the lead of the component into the tag and clamping it, heating the joint by means of the soldering iron and making the joint by adding soldering tin)

6. What steps are required for replacing a component in Fig. 21?

"A" (Defective component to be cut off at the kinks of the leads; leads of new component to be cut to required length, to be tin-coated and soldered)

7. What are the causes for a bad soldered-joint showing the following faults?

a) grey surface b) bad bond of solder

"A" (a) grey surface: soldering temperature too high, soldering tin is burnt,
 conductor has been moved during cooling.

(b) Bad bond of solder: dirty wires or soldering tags)

8. Why must stripped wires not be notched?

"A" (Notches may break the wire in the wrapping process)

9. Why must wire-wrap joints have a certain strength?

"A" (To provide a proper mechanical and electric connection)

10. What are the advantages of notched joints over soldered joints?

"A" (Less amount of work; no accessories required, such as flux, soldering tin and soldering devices)

11. Which tools are required for cleaning of conductors depending on the cross section?

"A" (Cross section up to 1 mm²: scraper
cross section up to 35 mm²: cable
 stripper
cross section exceeding 35 mm²: wire brush)

12. How is a notched joint checked for firm seat?

"A" (By tensile loading)

13. What cross section of copper or aluminium conductors can be pressed?

"A" (Copper of 0.75... 120 mm² and aluminium of 16... 185 mm² can be pressed)

14. What is important when using pressing tools?

"A" (Application of the pressing tool; conductor and cable eye must be of the same material)

15. Why must the flash at the cable eye be removed after pressing?

"A" (To avoid injury, such as cuts or laceration)

16. What steps are required for making the various types of joints?

"A" soldered joint	wire-wrap joint	notched joint	pressed joint
1. Cutting to length and stripping of conductor			
2. Cleaning of soldering surface	Feeding the wire into the wrapping mandrel	Cleaning of conductor	
3. Flux-treatment of soldering surface	Making the wire-wrap joint	Feeding the conductor into the cable eye or sleeve	
4. Tin-coating of soldering surface	Inspection of wire-wrap joint	Making the notched joint	Making the pressed joint
5. Making the soldered joint		Inspection of the joint made	
6. Inspection of the soldered joint			