

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

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1. Aims and Contents of Practical Vocational Training in the Working Techniques of "Making Fastening 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 fastening joints (detachable 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 and applications of the tools.
- Steps of work required for making fastening (detachable) joints.
- Quality requirements for fastening (detachable) joints.
- Labour safety requirements.

Skills

- Handling of tools.
- Maintenance and servicing of tools.
- Direct connection of conductors.
- Indirect connection of conductors.
- Making plug-type 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:

- Screwdrivers and wrenches must be suitable for the size of the screw or nut.
- Screwdrivers and wrenches must be applied correctly to prevent slipping off.
- When using screwdrivers, never put the hand under the screw for counterpressure. The screwdriver might slip off and produce a dangerous stab.
- Unscrew/slacken rusty screws or nuts by means of ring wrenches (if possible).
- Cover sharp edges with textiles (if possible).
- Never hold your face over the screw joint to be tightened or unscrewed. The screw or nut might be thrown into your face when it shears off.
- 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 teaching aids

- The theoretical instructions should be given at a place where the trainees are able to make notes, preferably in a class-room with blackboard, desk 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:
 - tools for preparing the conductors, various terminals (with and without distributor plates), tools for making fastening joints (detachable joints).
 - For indirect connection of conductors: prepared conductors with cable eyes, terminals, tools for making fastening joints (detachable joints).
 - For making plug-type joints, devices/appliances or installations, which are in operation in the shop, should be used as examples.
- Sufficient copies of the "Trainees' Handbook of Lessons – Making Fastening 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 fastening joints (detachable 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 Fastening 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 for the planned exercises.

Recommended basic equipment:

- Screwdrivers 2, 4, 6, 8, 10 mm
- Double head (open ended) wrenches and box wrenches (socket wrenches) from 5.5 to 17 mm opening or ring wrenches
- Combination plier
- Round nose plier
- Adjusting plier
- Side cutting plier
- Stripping plier
- Cable stripper
- Scraper
- Hand hacksaw with metal saw blade
- Bastard file and smooth file 200 mm (half round)
- Hammer
- Soldering iron
- Soldering flux
- Spirit.

2.4. Time Planning

Based on the total hours available, the times for the individual training sections of this lessons 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.
- Exercise/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 by practising. Any waiting times occurring for the trainees in spite of good planning should be bridges by suitable preparatory work, such as preparation of conductor material.

3. Recommendations for Realizing the Practical Vocational Training in the Working Techniques of "Making Fastening 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 and of making permanent joints should be repeated and referred to since a good command of those working techniques is a precondition for acquiring the working techniques of "Making Fastening Joints".

The knowledge and skills of "Making fastening joints" should be taught intensively using all teaching aids available.

Types and meaning of fastening joints (detachable joints)

In order to make clear the types and meaning of detachable joints, it is recommended to show to the trainees finished joints, such as screw or plug-type joints.

The applications of detachable joints in practice, their advantages as well as possibilities of making them can then be derived in discussions with the trainees.

Tools for making fastening joints (detachable joints)

Original tools should be used to explain the design, applications and handling of the tools required and used for making screw-type joints. Possible defects of tools and their causes should also be discussed. For this purpose, damaged tools should be shown to the trainees, such as broken handles or blades of screwdrivers, enlarged wrenches, etc.

To test the trainees knowledge, the instructor should show tools and let the trainees repeat their design and handling. Then the trainees should answer the questions in the "Trainees' Handbook of Lessons". The answers are to be checked by the instructor for correctness.

Direct Connection

In this working technique the trainees shall acquire basic skills and abilities for direct connection of different conductor materials.

The emphasis should be on the following points:

- Correct preparation of the conductor to be connected.
- Bending of wire lugs.
- Use and handling of the tools.
- Observing the rules for connection.
- Meeting the labour safety requirements.

In practice, there is a variety of forms of clamped joints. The different forms require different sequences of operations for direct connection.

The following sequences of operations and their systematic procedure are to be explained and demonstrated to the trainees:

- Sequence of operations for making a wire lug
 - Stripping of the conductor
 - Bending of the wire lug
- Sequence of operations for connecting wire lugs
 - Unscrewing of the fastening screw
 - Composing the screw assembly
 - Tightening of the fastening screw
- Sequence of operations for straight–line connection
 - Stripping of the conductor
 - Unscrewing of the fastening screw
 - Feeding in of the conductor into the clamped joint
 - Tightening of the fastening screw.

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 the sequence of operations necessary for direct connection. It is important

- that each sequence of operations is individually demonstrated,
- that the instructor explains the purpose of his activities during the demonstration,
- that the trainees realize that direct connection 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 direct connection. The exercises can be carried out using any conductor materials and connectors available. It is recommended to have the exercises carried out in the order of the sequences of operations taught. The examples from the "Instruction Examples for Practical Vocational Training" may also be used for practising.

For carrying out the work it is recommended to determine criteria for observation and evaluation, such as:

Stripping of the conductor

- Does the trainee use the right tool?
- Does the stripped length comply with the relevant joint?
- Is the conductor undamaged?

Bending of the wire lug

- Does the inside diameter of the wire lug comply with the outside diameter of the screw?
- Is the centre of the wire lug in line with the centre line of the wire?
- Is the bent wire lug circular?

Connection of wire lugs

- Is the screw joint firmly tightened?
- Have the rules for composing the screw assembly been observed?
- Has the wire lug been correctly inserted in the screw joint?

Straight–line connection

- Does the stripped length comply with the clamped joint?
- Has the wire been put correctly into the clamped joint?
- Is the screw joint firmly tightened?

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

Indirect connection

In this working technique the trainees shall acquire basic skills and abilities for indirect connection.

The emphasis should be on the following main points:

- Making fastening joints (detachable joints).
- Observing the rules for connection.
- Use and handling of the tools.
- Meeting the labour safety requirements.

The trainees should already have a good command of making detachable joints which is a pre–condition for indirect connection. The other main points of indirect connection have already been taught for direct connection. Therefore, it is possible to have the technological sequence described and demonstrated by trainees. Any mistakes are to be corrected by other trainees in the form of discussions. Then the instructor should point out the possibility of combination of direct and indirect connection. Practical skills already acquired should be consolidated by further exercises according to the criteria of evaluation for indirect connection.

Plug–type joints (plug–and–socket connectors)

In this working technique the trainees shall acquire the necessary knowledge and skills for working with plug–type joints.

The emphasis should be on the following main points:

- Types and design of plug–and–socket connectors.
- Applications of plug–and–socket connectors.
- Rules for working with plug–and–socket connectors.

At first the instructor should explain the fundamentals, such as types, design and applications. After such introduction, the disconnection and connection of plug–type joints is to be demonstrated to the trainees by means of plug–and–socket connectors used in the factory. Any pulling tools necessary are to be shown and their handling is to be explained.

After the demonstration a repetition by the trainees is recommended. Any mistakes should be immediately corrected.

Further development of practical skills is recommended only if the trainees have to do repair or similar work on such devices, appliances or installation. This will avoid early fatigue of plug–and–socket connectors.

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 fastening joints (detachable joints) by direct connection and indirect connection. Moreover, the recommended materials, and a list of the necessary working, measuring and testing tools as well as accessories are included for each example. Thus the trainees have any information required for properly doing the exercises.

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

- The trainees should do himself any work involved in the instruction example, from preparing the initial material up to completion of the exercise. 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 detachable joints (fastening joints)?

(Joints which can be detached without damaging the joining elements and can be re-used.)

2. What tools are mainly required for making detachable joints?

(Screwdrivers, wrenches)

3. What are the effects when using a screwdriver the blade of which is too small?

"A" (The screwdriver blade will be damaged; the screw cannot be unscrewed because of insufficient force transmitted.)

4. Why must a screwdriver with defective handle not be used?

"A" (Risk of injury of hands.)

5. Why must the size of the screw/nut comply with the opening of the wrench?

"A" (If the opening is too small, it will not fit onto the screw or nut. If the opening is too big, the screw or nut will be damaged. The wrench will not drive the screw or nut, there is the risk of injury when slipping off.)

6. What tool can be used for slackening a nut if no suitable wrench is available?

"A" (Flat nose plier, combination plier, water pump plier.)

7. Why must no more than two aluminium conductors be connected to a connection bolt?

"A" (Aluminium conductors shrink in cross section. If more than two conductors are connected, the pressure piece cannot compensate for it.)

8. What tools are used for stripping of conductors?

"A" (Scraper, stripping plier, cable stripper.)

9. Why must the wire lug be bigger than the connection bolt?

"A" (The wire lug must easily go on the connection bolt.)

10. What tool is used for unscrewing a slotted screw and a hexagon-head screw?

"A" (Slotted screw – screwdriver, hexagon-head screw – wrench.)

11. What is the sequence of operations for making a bolt joint with 4 aluminium conductors?

"A" (– Stripping of the conductor.

– Bending of the wire lug.

– Composing of the bolt assembly in the following order:

- washer
- wire lug 1
- washer
- wire lug 2
- washer
- lock washer 1
- nut 1
- washer
- wire lug 3
- washer
- wire lug 4
- washer
- lock washer 2
- nut 2

– Tightening of the fastening nuts)

12. Why must the wire be applied at the left-hand side of a distributor plate?

"A" (Because the wire shall be drawn into the screw joint during tightening.)

13. What is the sequence of operations for connecting a protective conductor with cable eye to a screw connector?

"A" (Unscrewing the screw, putting the lock washer or serrated lock washer onto the screw, putting the cable eye on, screwing the complete screw in by hand, tightening the screw by screwdriver)