

**Handling and Connection of Cables and Lines for Fixed Laying –
Course: Basic Skills and Knowledge of Electrical Engineering.
Trainees' Handbook of Lessons**

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Introduction

The present handbook is intended for trainees in electrical engineering trades.

It contains a description of the operations and tools required for the handling and connection of cables and lines for fixed laying.

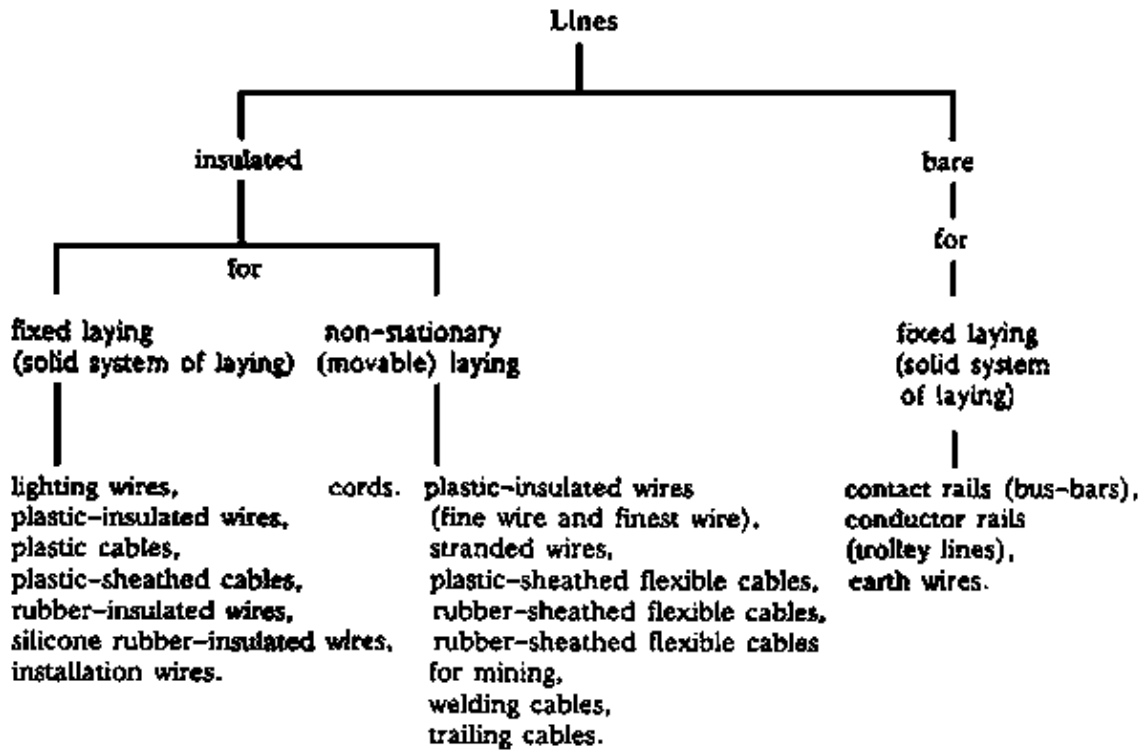
The methods required are explained in self-contained sections.

The necessary knowledge and skills are described in each section in the order of the steps of work required. The illustrations contained shall help to visualize, understand and supplement the text of the individual sections.

To assist the learning process, questions have been included for the trainees to test their knowledge.

1. Fundamentals for Handling and Connection of Cables and Lines for Fixed Laying

Classification of lines (survey)



Insulated lines

- Conductors are provided with plastic or rubber insulation (conductor insulation).
- Several conductors are stranded and sheathed by a common insulation (insulation sheath).

Bare lines

- Uninsulated conductors.

Lines for fixed laying (solid system of laying)

- Lines are fixed (permanently installed)

Lines for non-stationary laying (connection to portable equipment)

- Flexible (movable) insulated lines.

Features of lines for fixed laying

- Conductor of lines for fixed laying
- Conductor
 - single wire, code designation (e)
 - multi-wire, code designation (m)
 - round, code designation (r)
 - segmental, code designation (s)
- Wire insulation and insulation sheath can be slightly bent. (Bending radius to be considered)
- Line is intended for single laying and subsequent continuous operation (in unchanging position).

What is the difference of lines and cables for fixed laying compared to those for connection of non-stationary (mobile) equipment?

Examples of applications of cables and lines for fixed laying

Type of line	Indoors			Outdoors	Applications
	dry	humid	wet		
Plastic insulated wire	+				Installations, switchgear and distribution systems; light fittings
Plastic cables and plastic-sheathed cables	+	+	+	+	Installations of any kind
Installation wires	+				Concealed installation



Figure 1 Plastic-insulated line, single-insulation, single-wire, (Cu – NY, Al – NAY)



Figure 2 Plastic cable, double-insulation, multi-wire, (Cu – NYY 1 x 50 mm², Al-NAYY 1 x 50 mm²)



Figure 3 Plastic cable, multiple insulation, multi-core, single-wire, (Cu – NYY-I 4 x 2.5 mm² re, Al – NAYY-I 4 x 2.5 mm² re)



Figure 4 Plastic cable, multiple insulation, metal sheath, three-core, multi-wire, Al conductors

What are the criteria for the selection and application of cables and lines for fixed laying?

Operations required before the connection of the lines

- Bending of lugs
- Pressing-on of cable eyes
- Making pressed joints of conductors
- Soldering on conductors

2. Handling of Cables and Lines for Fixed Laying

The insulation can be removed by means of the following tools:

- cable stripper
- sheath stripper
- insulation stripping plier

Stripping process for a plastic–sheathed cable

Stripping of the insulation sheath

By means of the cable stripper

- Apply cable stripper angularly.
- Rip up the insulation sheath of the cable parallel to the conductor. (The knife is to be held at such an angle to the conductor that the knife blade cannot damage the conductor insulation).
- Tear apart the plastic sheath.
- Carefully cut off the insulation sheath all around.

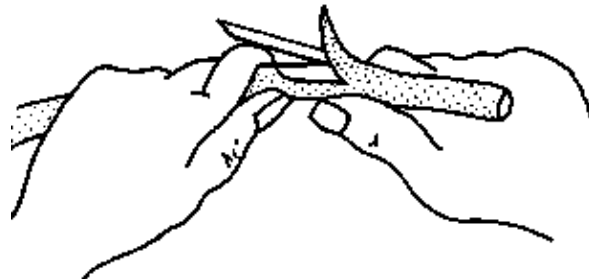


Figure 5 Stripping of the insulation sheath by means of cable stripper

For stripping of insulation use knife with sharp blade only!

By means of the sheath stripper

- Set adjustable blade according to the line diameter.
- Put the stripper on the line.
- Rip up the sheath.
- Tear apart the plastic sheath.
- Carefully cut off the insulation sheath all around.

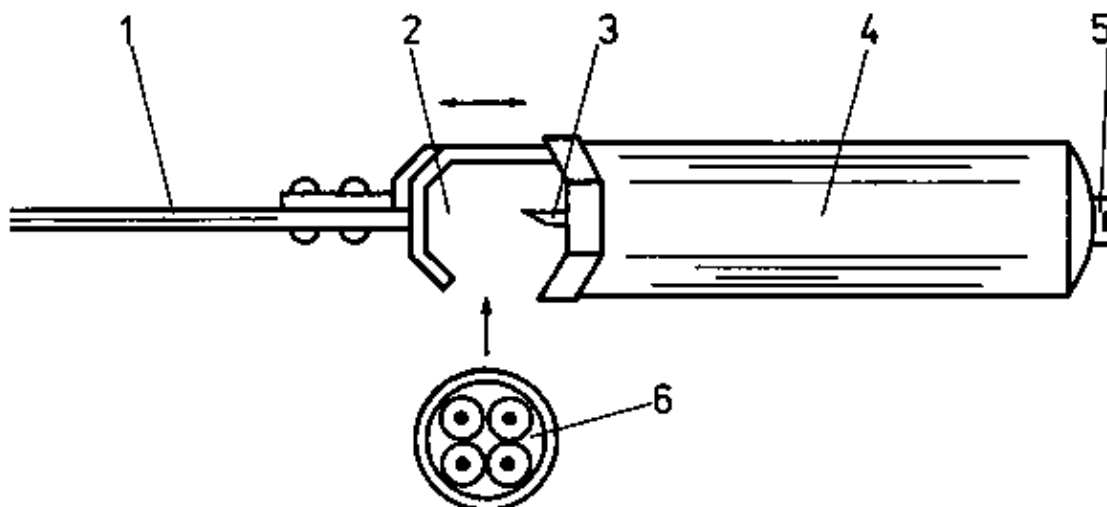


Figure 6 Sheath stripper for removing the insulation sheath from plastic–sheathed cables

1 blade, 2 area for the cable, 3 adjustable blade for scoring the insulation sheath, 4 handle, 5 adjusting screw for setting the blade, 6 cable

Removal of the filler

- Completely remove the filling material under the sheath up to the insulation from the stripped end of the cable.

Removal of the conductor insulation

By means of the cable stripper

- Cut off (peel off) one half of the insulation by means of the knife.
- Pull off the other half by hand and cut off by means of the knife.

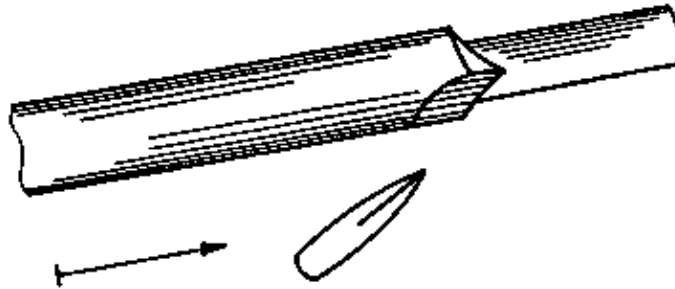


Figure 7 Stripping of the conductor insulation by means of the cable stripper

Make sure that the knife is guided correctly since the conductor may be damaged by wrong knife guidance and may break when being bent.

What are the risks involved in a conductor which has been damaged when stripping the conductor insulation?

By means of the insulation stripping plier

- Set adjustable stripping blades according to the cross section of the conductor.
- Put conductor into the pair of noses of the stripping plier and operate the stripping plier.

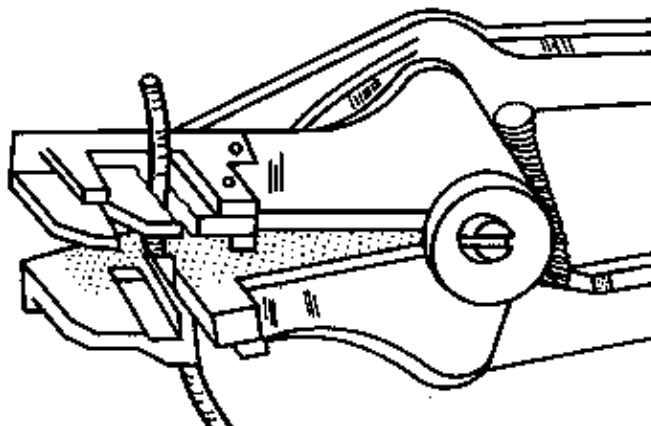


Figure 8 Stripping of the conductor insulation by means of an insulation stripping plier

Only use the cutting edge suitable and marked for the relevant conductor cross-section. Conductor cross-sections exceeding 6 mm² are to be stripped by means of the cable stripper!

For bending of wire lugs and pressing-on of cable eyelets see “Trainees’ Handbook of Lessons” of Making Fastening Joints” and “Making Permanent Joints”.

What is to be considered for bending of wire lugs?

What is to be considered for making a joint with wire lugs?

What is to be considered for pressing-on cable eyelets?

3. Connection of Cables and Lines for Fixed Laying to Electrical Equipment

Cables and lines of up to 4 mm² (inclusive) are to be laid with a spare loop at the points of connection so that the conductor can be re-adjusted.

The cross section of conductors must **not** be reduced at their points of connection and joints. Points of the connection and joints must be easily accessible!

The colour of the core must comply with the function of the conductor!

Example for making of lines for use in heavy current installations of up to 1 kV

Function of the conductor		Colour of the insulation
Main circuits	also auxiliary circuits for industrial controls	black
	preferably, however, as middle wire (neutral wire) with no protective function	blue
	also auxiliary circuits having switch contacts	brown
Protective wires (neutral wires, auxiliary earth wires), potential equalization wires		green-yellow

3.1. Making Screw Joints

- Before the lines are fed into and connected in the electrical equipment, it is recommended to strip (remove) the insulation as per section 2 hereof.
- For the stripping length, the arrangement of the connections in the equipment is important.
- The connecting lines are to be fed into the connection area of the electrical equipment with their entire sheathing.
- The sheathing of the line must project into the equipment approximately 3 mm.

- When feeding-in lines into equipment with screw joints (e.g. moisture-proof equipment), correct assembly of the screw joint is of utmost importance.

Feeding-in the line with the sheathing prevents the conductor insulation from being worn through by sharp edges of the equipment and, consequently, eliminates possible sources of faults!

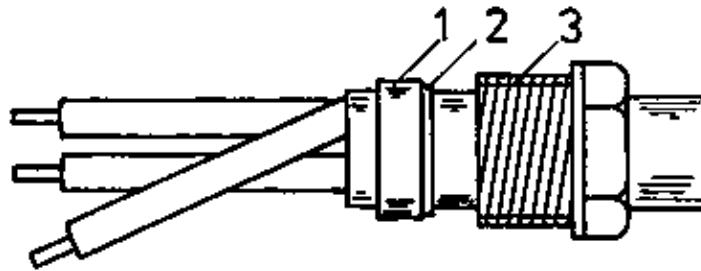


Figure 9 Arrangement of the elements when assembling a gland screw joint

1 sealing ring, 2 pressure ring, 3 plug

- The conductor insulation must end 1 mm before the point of clamping.

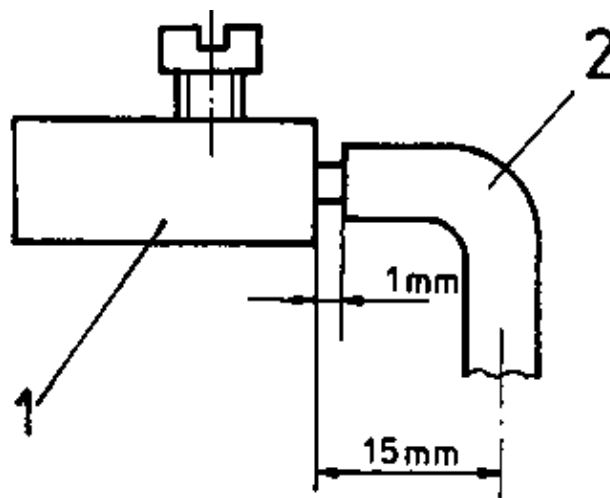


Figure 10 Connection of a conductor to a terminal

1 terminal, 2 conductor

Clamping of the conductor insulation might be detrimental to the function of the connection!

Conductors stripped too much may result in short circuits!

When are lugs to be bent for clamped connections?

- One conductor only is to be connected to terminals of installation switches, sockets and electrical equipment
- Points of connection and joints must not be covered by other conductors.
- Conductors are to be connected only in the direction of rotation of the clamping screw.

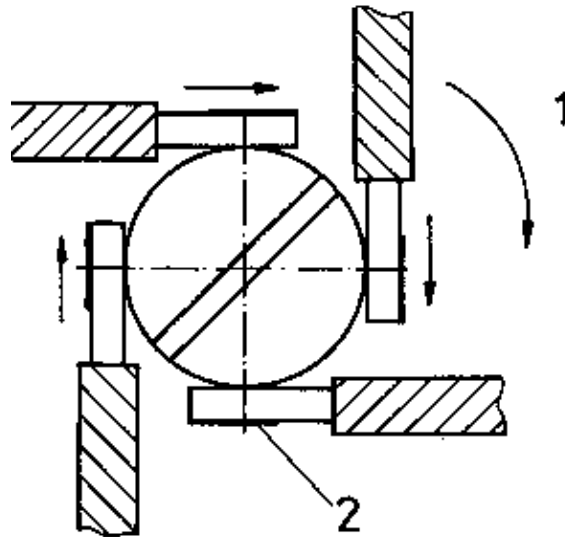


Figure 11 Connection of 4 conductors to one terminal with distributor plate

1 direction of rotation of the screw, 2 distributor plate

- Aluminium conductors are slightly to be greased with acidless grease (anti-corrosive grease) before they are clamped.
- If Cu and Al conductors are to be jointly clamped to one joint, it is to be made sure that the two conductors are not in direct contact.

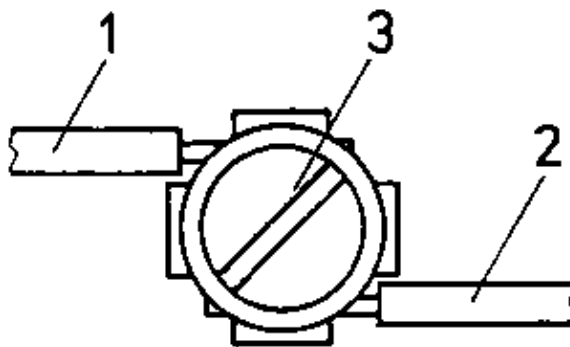


Figure 12 Connection of a Cu conductor and Al conductor to one terminal

1 Cu conductor, 2 Al conductor, 3 terminal

- The clamped conductor must be supported by the whole contact area of the point of connection or joint.
- If several conductors are connected to one connection bolt, it is to be made sure that a washer is inserted between the conductors and a lock washer at least after every three conductors.

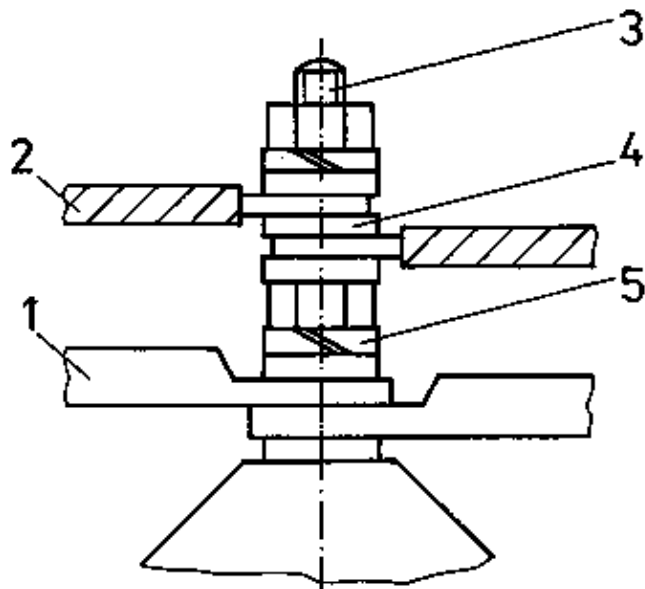


Figure 13 Connection to a connection bolt

1 cable eye, 2 conductor with lug, 3 connection bolt, 4 washer, 5 lock washer

- For connections of protective conductors or middle conductors **one** conductor per point of connection is admissible only.
- Series connection of the protective conductor from built-in unit to built-in unit is admissible only if the protective conductor is looped.

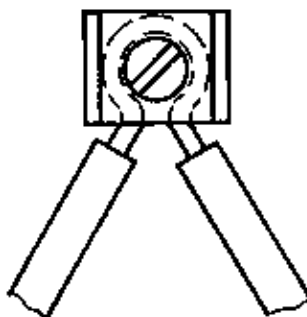


Figure 14 Looping of a line over a terminal

Looped lines are admissible only within one assembly (e.g. from lamp to lamp within one luminous band).

- When connecting a cable eye and a lug to a connection bolt, the cable eye and lug must be separately connected. (See also Figure 15)
- When connecting conductors to cap screws without clamping saddle or distributor plate, no more than three conductors, which may differ by up to two cross-sectional steps, must be connected with one washer each to be inserted between the conductors.

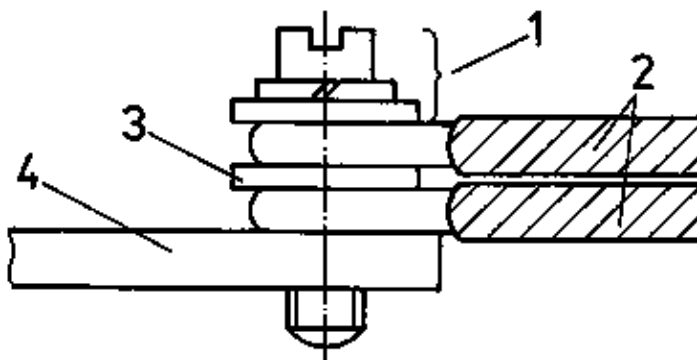


Figure 15 Connection to a connection strap with cap screw without clamping saddle

1 pressure elements (cap screw, lock washer, washer), 2 conductor, 3 washer, 4 connection strap

– When connecting conductors to cap screw with clamping saddle, one conductor only must be connected per saddle side. (The conductors may differ by one cross-sectional step.)

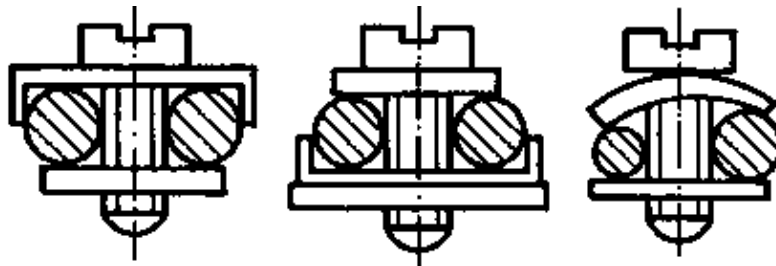


Figure 16 Connection to cap screw terminals with clamping saddle

– When connecting conductors to cap screws with distributor plate, one conductor only must be connected per distributor plate. (The conductors **must** have the same cross section).

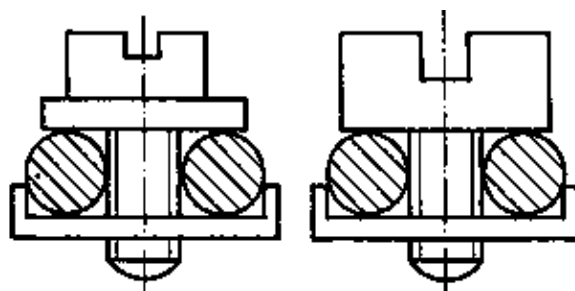


Figure 17 Connection with cap screw and distributor plate

– Conductors to be connected to connection bolts or screws with no connection facilities must have at least the following cross sections:

Screw/bolts	Minimum cross section
M 3 to M6	1 mm ²
M 8	1.5 mm ²
M 10	4 mm ²
M 12	6 mm ²
M 16	10 mm ²

Washers used for connection of conductors to screws or bolts must cover at least two thirds of the conductor!

Screw slots must not be damaged by wrong-size or defective screwdrivers!

3.2. Criteria for Clamped Joints in Electrical Installations

– For clamped connections of lamps it is important that the neutral conductor is always connected to the ring contact and the switch-lamp-wire always to the floor contact.

– Disconnection through switches is allowed for phase conductors only.

– Switches are to be connected so that the so-called TRR rule is observed, i.e. the circuit is closed when the switch is in

- top position
- rear position
- right-hand position.

– For connection of switches, attention is to be paid to switch connection marks. (Always connect phase conductors to the terminals marked accordingly.)

– For connection of sockets, the phase conductors are to be clamped at the left-hand side and the neutral conductor with protective conductor function (PEN) or the neutral conductor and protective conductor at the right-hand side.

– The phase conductor sequence (e.g. in the order black, blue, brown) is to be observed when connecting power sockets and other installation units.

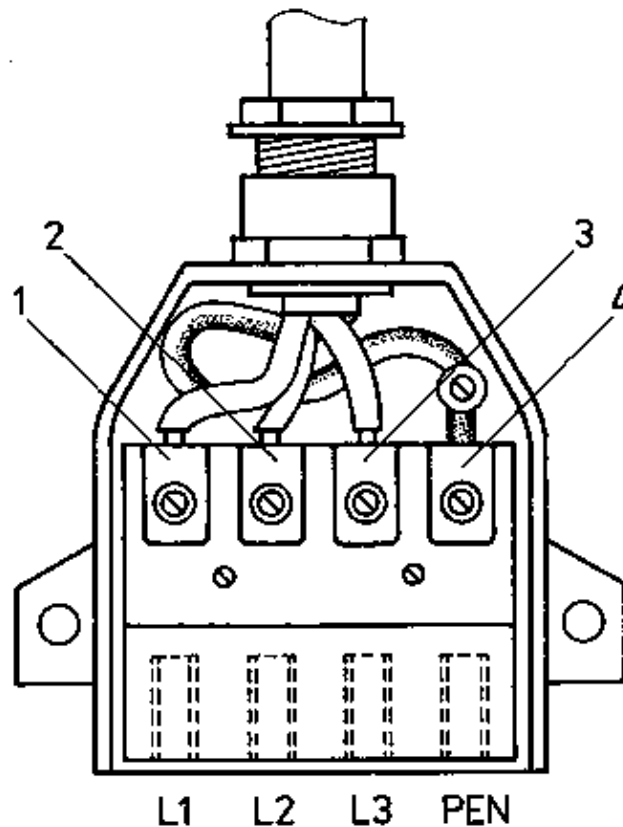


Figure 18 Connecting of a power socket

1 conductor 1, 2 conductor 2, 3 conductor 3, 4 PEN, phase conductor sequence, for example, black, blue, brown, green/yellow starting with conductor 1

Non-observance of the correct phase sequence within an installation will result in malfunctions, such as wrong direction of rotation of motors etc.

– In branch or conduit boxes, the phase conductors are to be connected on the left-hand top and the neutral conductor or neutral conductor with protective function on the right-hand bottom.

– If branch or conduit boxes have a fifth connection terminal, the protective conductor **only** is to be connected to that terminal.

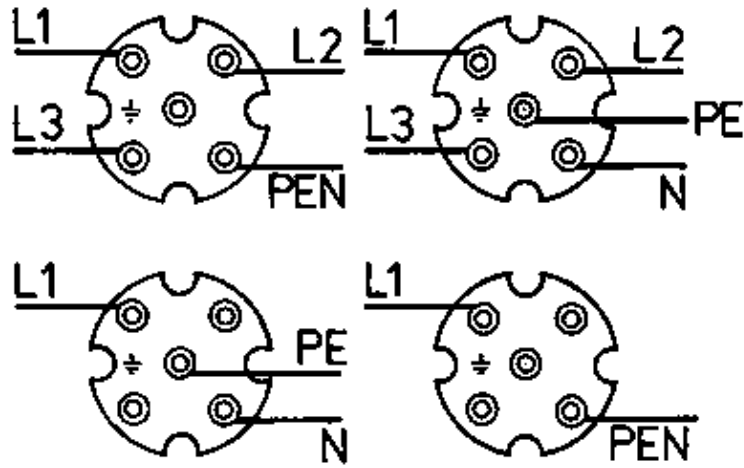


Figure 19 Examples for terminal connections in branch boxes

What are the advantages of a consistent system of clamped connections in electrical installations?

3.3. Pressed Joints

Criteria for connections by means of press-sleeves

- Hand pressing plier required.

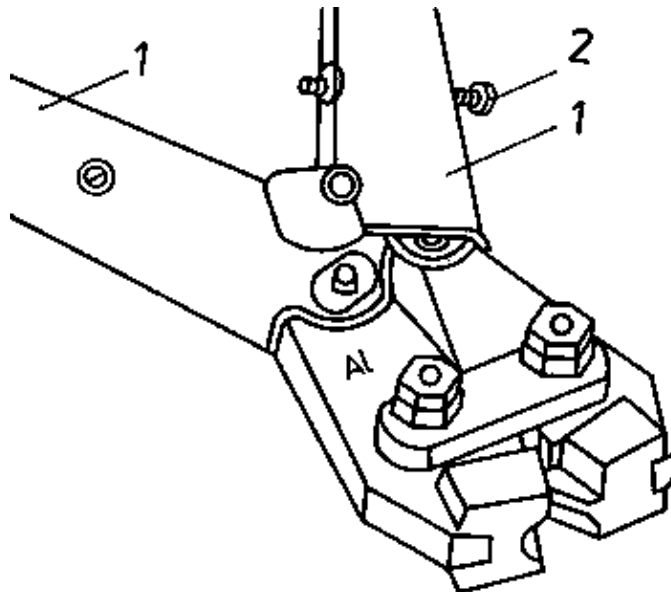


Figure 20 Pressing plier

1 grips with pawl bolt, 2 setscrew for mechanical end stop

- Applicable for Al and AlCu conductors only.
- Applicable only for three or four conductors with a cross section of 2.5 mm². (If two conductors are to be connected only, a third or fourth conductor is to be pressed in as filler).
- Shorter assembly time.
- Clamping inserts are not required.
- Longer lasting contact than that of other types of joints.

Sequence of operations

- Conductor length to permit three times re-adjustment. (150 mm are sufficient)
- Strip conductor ends and remove any oxide or other contamination layers.

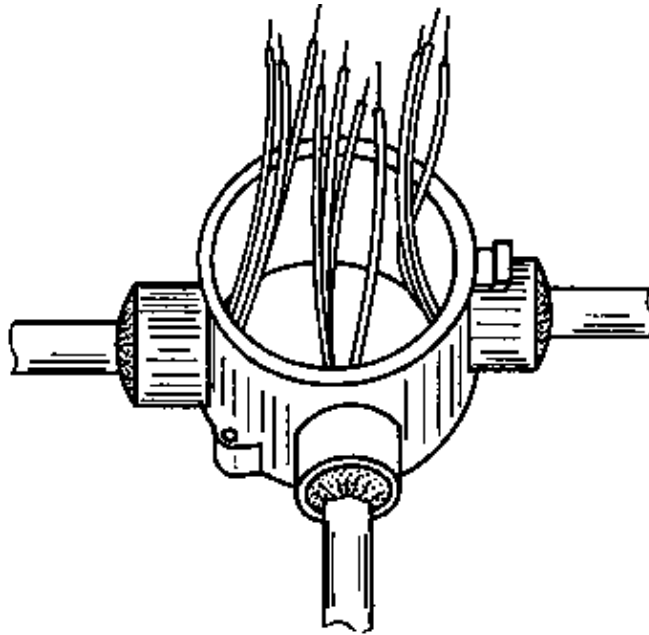


Figure 21 Branch box prepared for pressing

- Slip press-sleeve over stripped conductor ends with rotary motion. Make sure that all conductor ends contact the bottom of the sleeve!
- Distance between sleeve opening and beginning of conductor insulation should not be more than 3 mm!
- Apply pressing plier at front and compress up to stop.
- Slip insulation sleeve onto pressed sleeve until conical end of insulation sleeve closely fits on press-sleeve.

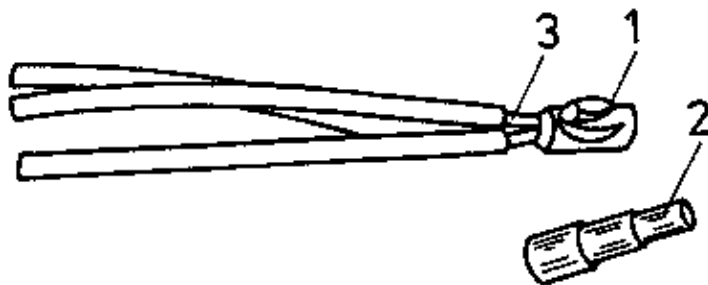


Figure 22 Finished pressed-joint

1 press-sleeve, 2 insulation sleeve, 3 distance sleeve opening to conductor insulation

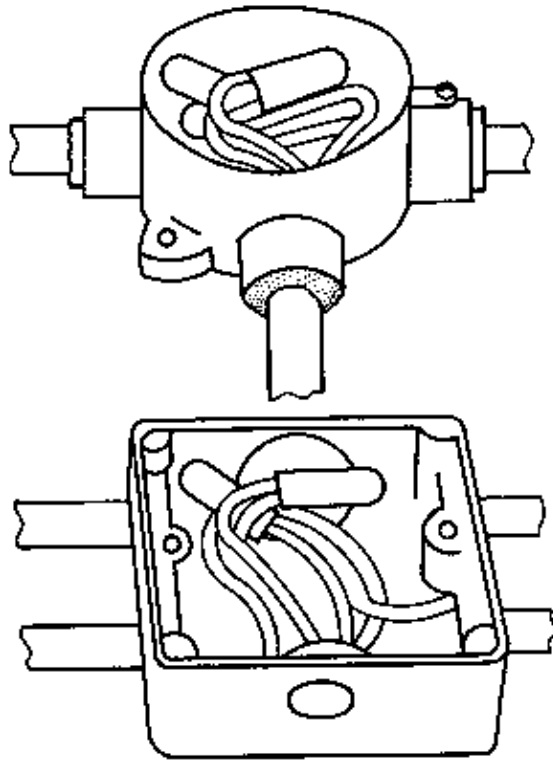


Figure 23 Pressed joint in a branch box/conduit box, made and insulated

What are the advantages of pressed joints over clamped joints?

3.4. Making Wire-wrap Joints

3.5. Making Soldered Joints

For these two types of joints see "Trainees' Handbook of Lessons – Making Permanent Joints".

What operations are required for making wire-wrap joints?

What operations are required for making soldered joints?
