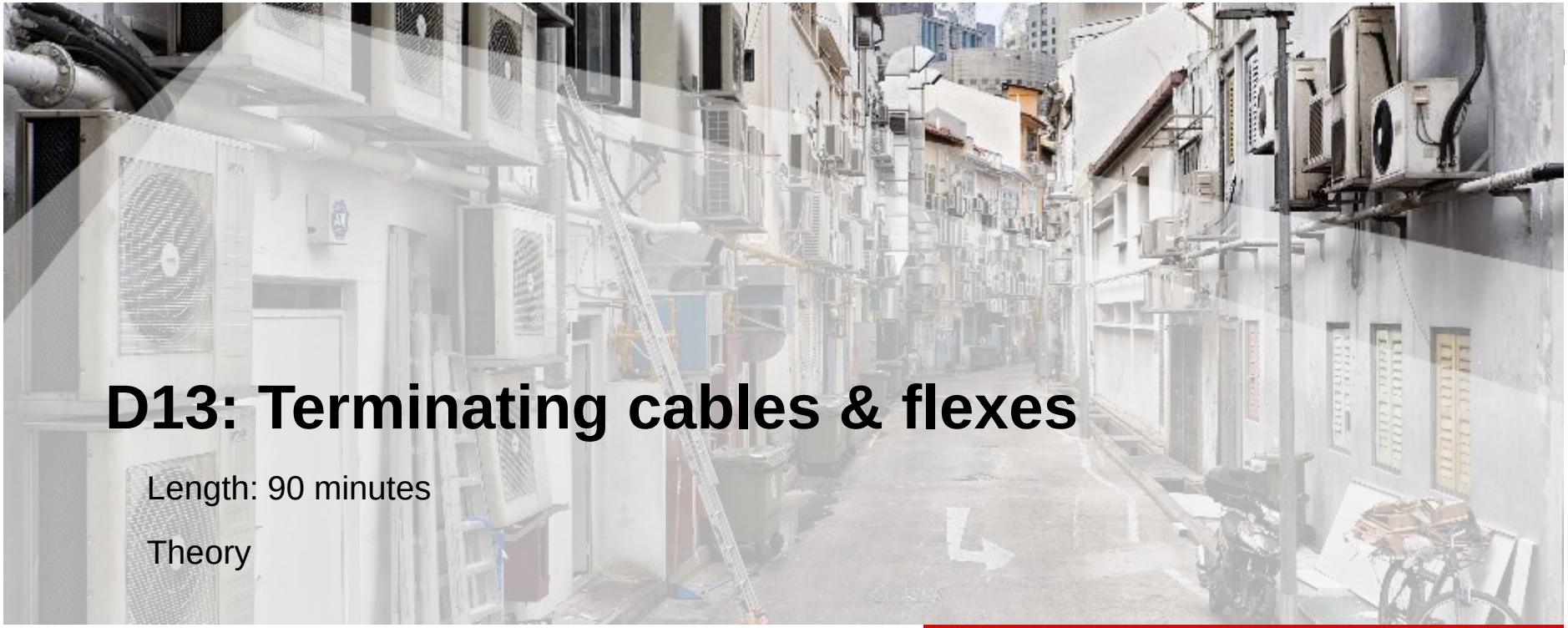


D13: Terminating cables & flexes

Length: 90 minutes

Theory

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Consultancy services provided by HEAT GmbH

Learning outcomes

- Know the basic types of cable and flex
- Know which factors affect selection of cables and flexes
- Be aware of harmonized cable colours
- Know the requirements for laying and fixing of cables
- Understand the different cable entry systems (cable glands)
- Be able to correctly terminate flexes into a plug
- Be able to correctly terminate cables using compression cable lugs

Agenda Module D13 Terminating cables & flexes

- Cable and Flexes

Terminating cables and flexible cords

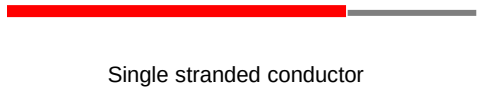
Basic types of cable / flex

Cable

Fixed wiring that is usually hidden in walls, floors (ground) and ceilings is done using cable, which is oval in cross-section and contains three or more wires.

Flex

Portable appliances and lights are connected to the fixed wiring system with flex, which is round in cross-section and contains two or three wires.



Single stranded conductor

Multi-stranded conductor

Termination

- The entry of a cable end into an accessory is known as a termination.
- In the case of a multi-stranded conductor, the strands should be twisted together before terminating.
- Where possible, any single strand conductors should be folded to ensure an effective connection. However, be careful not to damage the conductors.

Basic types of cable / flex

- A cable termination of any kind should securely anchor all the strands of the conductor and not impose any appreciable mechanical stress on the terminal or socket or any undue strain on the conductor itself.

- A termination under mechanical stress is liable to loosen or disconnect. When current is flowing, heat is developed, and the consequent expansion and contraction may be sufficient to allow a conductor under stress, particularly one under tension, to loosen or be pulled out of the terminal or socket.

- Unless the equipment manufacturer's instructions state otherwise, all conductors should preferably be of sufficient length to allow them to be terminated at least one more time.

Factors for selection of cables

Factors	Results for selection

• Installation location?
  ○ Outside or inside building
  ○ According to safety regulations for this installation
• Fixed or flexible installations
	Type of cable

• Which equipment must be supplied with electricity? • Type of electrical circuit? ○ Single phase, three-phase, with or without neutral conductor	Number of wires
• Minimum diameter of the conductor according to the requirements of the standards • Minimum current load capacity according to the requirements of the standards • Necessary protection for the operating equipment to be supplied • Current carrying capacity to prevent fires • Circuit breaking condition of the protective measures • Voltage drop	Diameter of the conductor

• Types of installations
  ○ Maximum mounting distances
  ○ Maximum bending radius
  ○ Strain relief
	Distance between fixing points

CENELEC harmonised system in Europe

Electrical cables were harmonized and standardized in Europe by CENELEC in 1976. The labelling of electrical cables gives information about the permissible voltage and the structure of the cable.

Exemplarily recommended cable applications (also for the use in RACHP installations) as defined in the harmonization standards are as follows (box):

	Examples
PVC cable (flex) (YSLY-JB) • Universally applicable: Flexible power, process control and instrumentation cable for industrial applications and mechanical engineering for indoor applications. • For installation in dry and damp rooms. • The cable is resistant to most usual chemicals, oil and grease. • Not suitable for constant motion.	 © Lapp Kabel
Rubber cable (flex) (H05RR-F / H07RN-F), • For use when cable is subjected to mechanical stress in dry or damp areas. • May be used as power supply cable for portable motors, appliances, domestic electric and electrical tools, and agricultural and utility water equipment. • May be installed on plaster or directly on structural parts of heavy machinery.	 © Lapp Kabel
PVC cable (flex) (H05VV-F), • For use in offices and domestic premises. Generally used for household appliances such as washing machine and refrigerators. • Permitted for cooking and heating applications, provided cable does not contact hot parts and is not subjected to radiation. • Not suitable for outdoor use and constant motion.	 © Lapp Kabel

Use of wire colours

For most cables, the wires are colour coded.

Wire	Europe, China, Singapore, Russia, Ukraine, Belarus, Kazakhstan, Argentina	US, Canada, South America and Japan, Thailand	Australia, New Zealand
Phase conductors	black, brown, grey	red, black	Red, white, others
Neutral	blue	white	Black, blue
Protective earth conductor and protective equipotential bonding conductor	green-yellow	green	Green-yellow, green

Cable laying and fixing

- Cable laying conditions and fixing distances for cables and wires depend on the type of material used.
- Local connection provisions, regulations and standards must be observed, especially for the laying of cables in buildings.
- Cables fixed to the surface should be neatly run and secured at regular intervals in accordance with the cable manufacturer's instructions (therefore some consultation may be required in order to obtain specific technical information).
- In addition, it is advised to use fixings that can withstand high temperatures.

Cable laying and fixing

- Movable cables are to be provided with a strain relief directly at the insertion point. This happens either with the cable gland or in the device or machine.
- Cables are to be inserted into electrical components and machines using appropriate cable glands, which provide the required IP protection, vibration elimination and strain relief.
- Usually flexible (chemical and oil resistant) cables are used and can be laid and installed within specific cable ducts, protective tubes or on appropriate cable racks.

Cable laying and fixing

Electrical installation example for a RACHP application

© HEAT GmbH

Electrical installation example for a RACHP application

Cable entry systems (Cable glands)

Cable glands are used to insert and guide electrical cables as well as corrugated hoses and pneumatic hoses in control cabinets, distribution boxes, terminal boxes, machines or vehicles.

Cable glands provide a certain degree of protection against:

- Ingress of water or dust
- Contact
- Sharp metallic edges
- Strain relieve when equipped with a lock nut

Cable entry systems (Cable glands)

© HEAT GmbH

Insertion of more than one cable into a compressor terminal box

The IP protection classification and strain relief are only secured if one cable is inserted! Passing of more than one cable through a cable gland is not permitted and voids the given certification (IP protection certification).

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State of the art cable laying and insertion into compressor terminal box

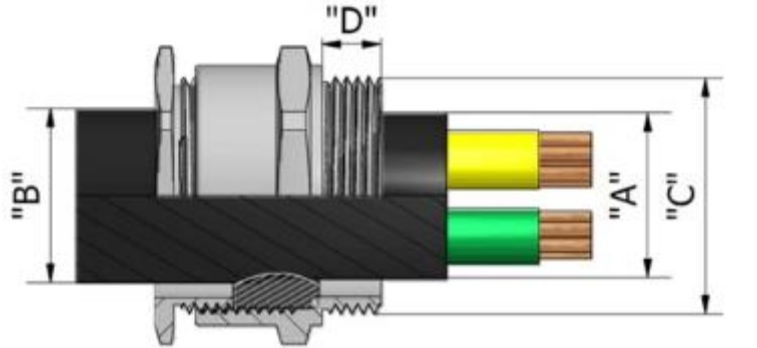
Electrical safety: suitable panel design and cabling

© HEAT GmbH

Example: compressor housing

Design of electrical panel assembly:

- Must comply with requirements of EN 60079-10. (Explosive atmospheres.)
- Use cable glands to feed electrical cables into the panel.
- Make sure that gland and cable size match.
- One cable per gland.
- Tighten the inner gasket after inserting the cable.



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Agenda Module D13 Terminating cables & flexes

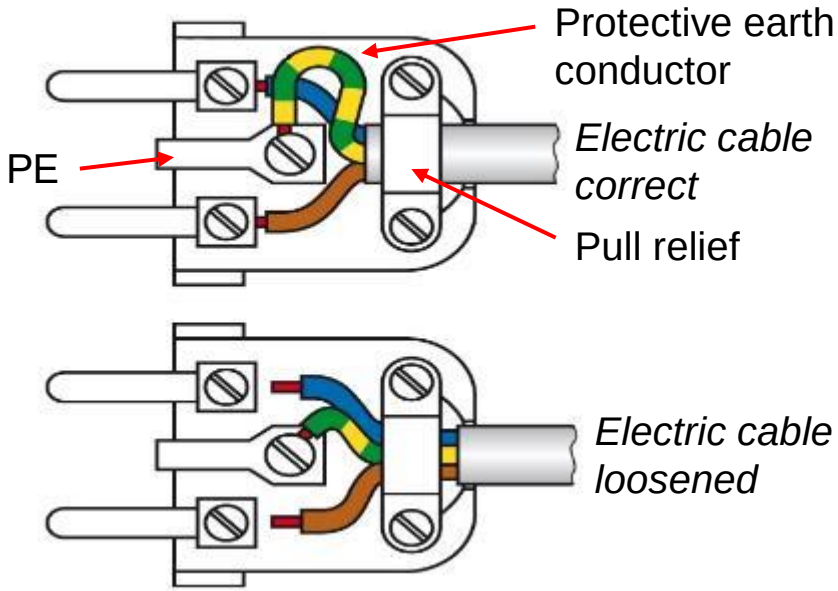
	Cable and Flexes
	Terminating cables and flexible cords

Terminating a plug to flexible cord

© HEAT GmbH
Example of a well terminated plug

- One or more strands, or wires, left out of the terminal or socket will reduce the effective cross-sectional area of the conductor at that point.
- This may result in overheating because further resistance has been introduced into the circuit.
- The same effect could occur with a loose connection.

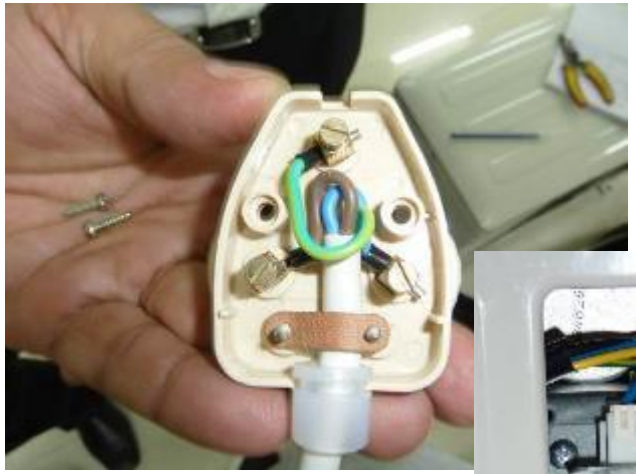
Terminating a plug to flexible cord



Correct plug installation

© Mouser

Terminating Cables and Flexible Cords



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Examples of suitable electrical installations

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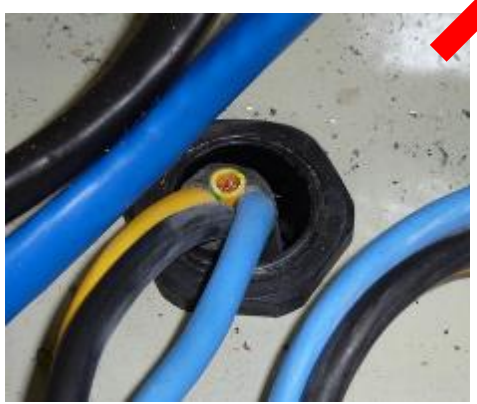
Terminating Cables and Flexible Cords

Here are some bad examples.



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Terminating flexible cords or cables

- Just the minimum amount of insulation should be removed to achieve an effective connection, with the terminal screw firmly clamping the conductor.
- Insulation should be removed using appropriate stripping tools; doing this will avoid damaging the conductor, its insulation and sheath.

Terminating flexible cords or cables

- For the preparation of flexible cable connections, use a wire-stripper plier.
- Side cutter plier or knifes should not be used!
- They can damage the thin individual copper wires.
- Damaged copper wires will cause arcing and scorching, and this may lead to the generation of sparks.
- Any of the wire strands cut and removed during the insulation stripping process reduces the cross sectional area of the conductor.
- This reduces the current carrying capacity of the cable and also will increase the conductor resistance.

© Knipex

Wire stripper for the use of cable connection preparation

Terminating flexible cords or cables

- In order to terminate conductors effectively, crimp terminals are extensively used.
- This type of connection is often used in the termination of bonding conductors to Earth clamps.
- The terminals are usually made of tinned sheet copper with silver-brazed seams.

The colour-coded crimp terminals represent the cable sizes they are designed for use with, and they are typically:

- RED = $0.75mm^2 – 1.5mm^2$
- BLUE = $1.5mm^2 – 2.5mm^2$
- YELLOW = $4mm^2 – 6mm^2$

Terminating flexible cords or cables

- Compression cable lugs have a thicker, sleeve-shaped conductor sleeve closed at the cable lug, which is deformed with crimping plier so that a force and form connection is maintained with the conductor.
- These electrical connectors, professionally prepared, will provide the best reliable connection and avoid arcing and scorching.

© Knipex

Insulated compression cable lugs

- For specific connections, the use of wire end ferrules ensures long-lasting electrical connections and avoid arcing and scorching.

© Knipex

Example of wire end ferrules

Terminating flexible cords or cables

To use the ratchet type crimping tool:

1. Remove sufficient insulation from the wire to be crimped, so that when the wire is inserted in the crimp, 1-2mm extends out from it.
2. Insert the wire into the crimp, making sure all strands are in, and none are left straying.
3. Carefully place the crimp and the inserted wire into the tool (you may find it easier to put the crimp into the tool prior to the wire with some crimps), and ensure the wire is seated home.
4. Cycle the tool until the tool releases.
5. Remove and inspect the crimp - ensure that the wire is in the correct position, and the insulation is gripped successfully.
6. Hold the crimp lug and give the wire a tug to ensure fully secured.

© Knipex

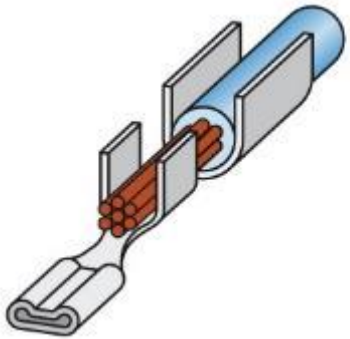
Ratchet type crimping tool with wire sleeves

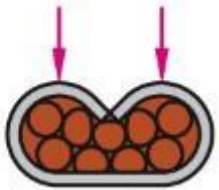
Terminating flexible cords or cables

Wire stripper

Wire end ferrules

Cable lugs





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GIZ Proklima

Contact:
Bernhard Siegele
E bernhard.siegele@giz.de
T +49 6196 79-1968
I www.giz.de/proklima

Author:
Anthony Darlow, Rolf Hühren
anthony.darlow@heat-international.eu; rolf.huehren@heat-international.de
HEAT GmbH, Königstein i. Ts., Germany

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PROKLIMA NATURALLY COOL

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Friedrich-Ebert-Allee 36 + 40
53113 Bonn, Germany
T +49 228 44 60 - 0
F +49 228 44 60 - 17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn, Germany
T +49 61 96 79 - 0
F +49 61 96 79 - 11 15

E info@giz.de
I www.giz.de

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH