



A grayscale, textured background image of a modern building with a glass facade and a prominent overhanging section.

# SAFETY IN ELECTRICAL ENGINEERING

v. 2022

## Safety of electrical equipment

**Is ability** of electrical equipment **not to threaten** (under specified operating conditions) **persons, livestock, or property** by danger caused by electrical current or other electrical effects and **to protect against dangerous non-electrical effect**, which could be caused by electrical equipment malfunction.

- Safe electrical installation (wiring)
- Safe electrical equipment (appliance)
- Skilled person

- **Power equipment**
  - **currents hazardous to persons, utility animals, property and objects may be generated** during normal use.
  
- **Low-power devices**
  - **currents hazardous to persons, service animals, property and effects cannot arise** during normal use.



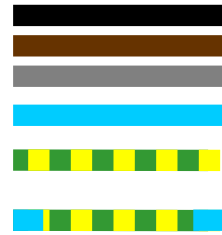
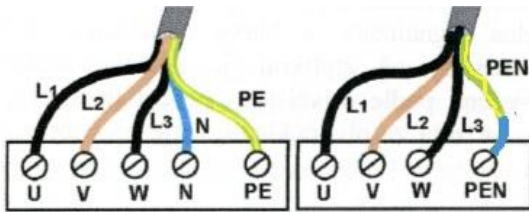
| Voltage category | Abbrev. (CZ/EN) |      | Voltage          | Nominal voltage $U$                     |   |   |
|------------------|-----------------|------|------------------|---|---|---|
|                  |                 |      |                  | earthed system                          |   | isolated system                         |
|                  |                 |      |                  | between conductor and earth             | between conductors                          | between conductors                      |
| I                | mn              | ELV  | Extra low, Small | $U \leq 50 \text{ V}$                   | $U \leq 50 \text{ V}$                       | $U \leq 50 \text{ V}$                   |
| II               | nn              | LV   | Low              | $50 \text{ V} < U \leq 600 \text{ V}$   | $50 \text{ V} < U \leq 1000 \text{ V}$      | $50 \text{ V} < U \leq 1000 \text{ V}$  |
| A                | vn              | (MV) | High             | $0,6 \text{ kV} < U < 30 \text{ kV}$    | $1 \text{ kV} < U < 52 \text{ kV}$          | $1 \text{ kV} < U < 52 \text{ kV}$      |
| B                | vvv             | HV   | Very high        | $30 \text{ kV} \leq U < 171 \text{ kV}$ | $52 \text{ kV} \leq U < 300 \text{ kV}$     | $52 \text{ kV} \leq U < 300 \text{ kV}$ |
| C                | zvn             |      | Extra high       | -                                       | $300 \text{ kV} \leq U \leq 800 \text{ kV}$ | -                                       |
| D                | uvv             |      | Ultra high       | -                                       | nad 800 kV                                  | -                                       |

Nominal voltage of AC socket in CR: **230/400 V** (three phase system)

| Designation               | Notation  |          | Name  | Mark       |            |
|---------------------------|-----------|----------|---|------------|------------|
|                           | Conductor | Terminal |   | Driver     | Clamp      |
| <b>Alternating system</b> |           |          | <b>Special types of wires and terminals</b>     |            |            |
| Phase                     | <b>L</b>  | <b>U</b> | Protective earthing                             | <b>PE</b>  | <b>PE</b>  |
| 1st phase                 | <b>L1</b> | <b>U</b> | Conductor with protective and neutral function  | <b>PEN</b> | <b>PEN</b> |
| 2nd phase                 | <b>L2</b> | <b>V</b> |   |            |            |
| 3rd phase                 | <b>L3</b> | <b>W</b> | Conductor with protective and mid-wire function | PEM        | PEM        |
| Neutral                   | <b>N</b>  | <b>N</b> |   |            |            |
| <b>DC system</b>          |           |          | Conductor with protective and line function     | PEL        | PEL        |
| Positive                  | L+        | + , C    |   |            |            |
| Negative                  | L-        | - , D    | Functional earthing                             | FE         | FE         |
| Mid-wire                  | M         | M        | Functional bounding                             | FB         | FB         |

## • AC supply system

– Insulated conductors



| Conductor |                     | Identification colour     |
|-----------|---------------------|---------------------------|
| L         | Phase               | black, brown, light gray  |
| N         | Neutral             | light blue                |
| PE        | Protective earthing | green/yellow              |
| PEN       | PEN conductor       | green/yellow + light blue |

– Bare conductors



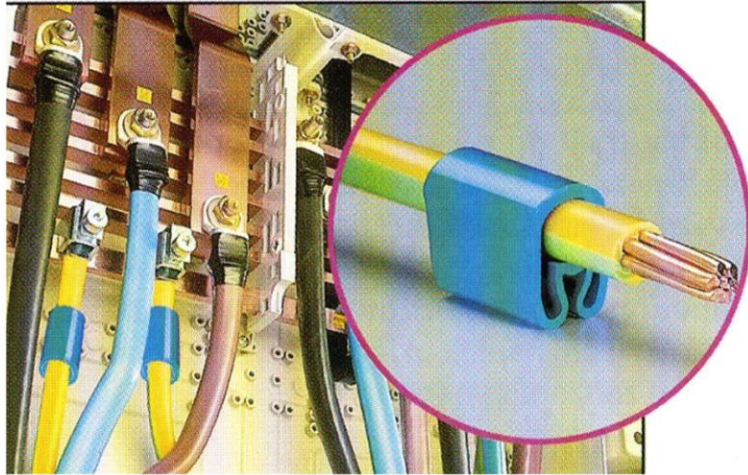
| Conductor |                     | Identification colour |
|-----------|---------------------|-----------------------|
| L         | Phase               | orange                |
| N         | Neutral             | light blue            |
| PE, PEN   | Protective earthing | green/yellow          |

## • DC supply system



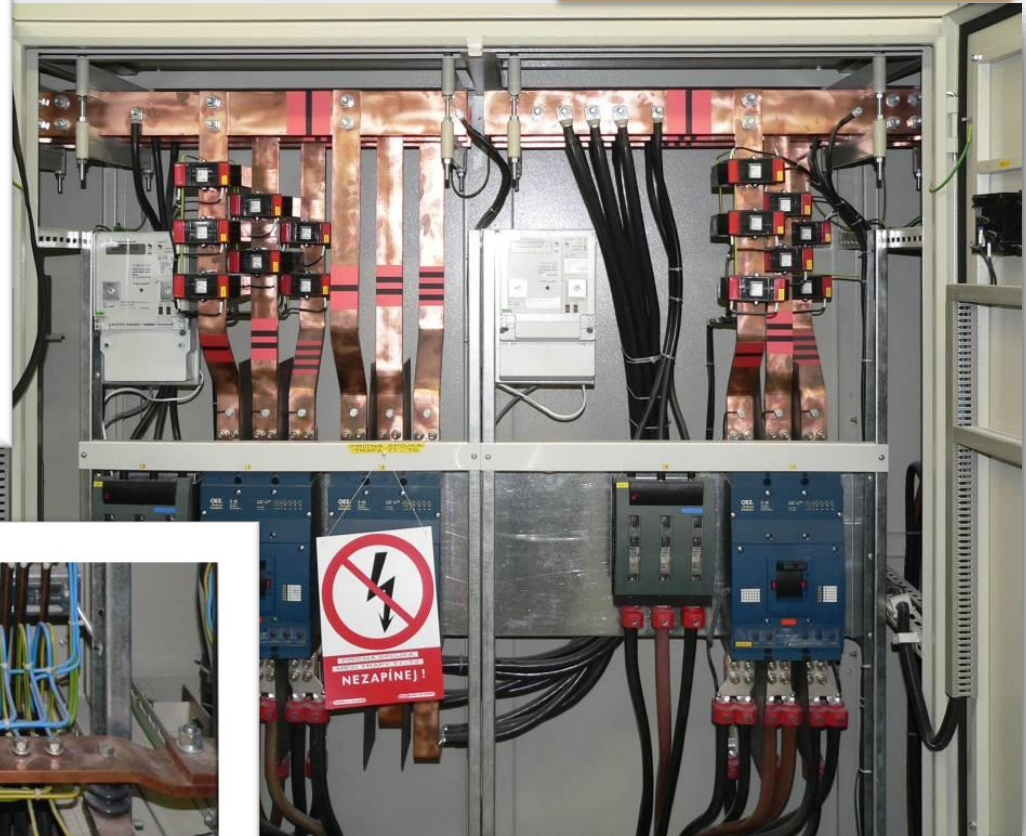
| Conductor |                     | Identification colour |
|-----------|---------------------|-----------------------|
| L+        | Positive            | dark red              |
| L-        | Negative            | dark blue             |
| M         | Mid-wire            | light blue            |
| PE, PEM   | Protective earthing | green/yellow          |



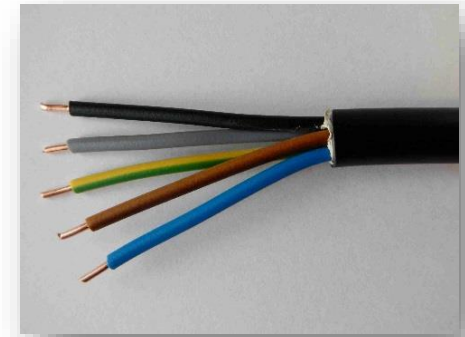
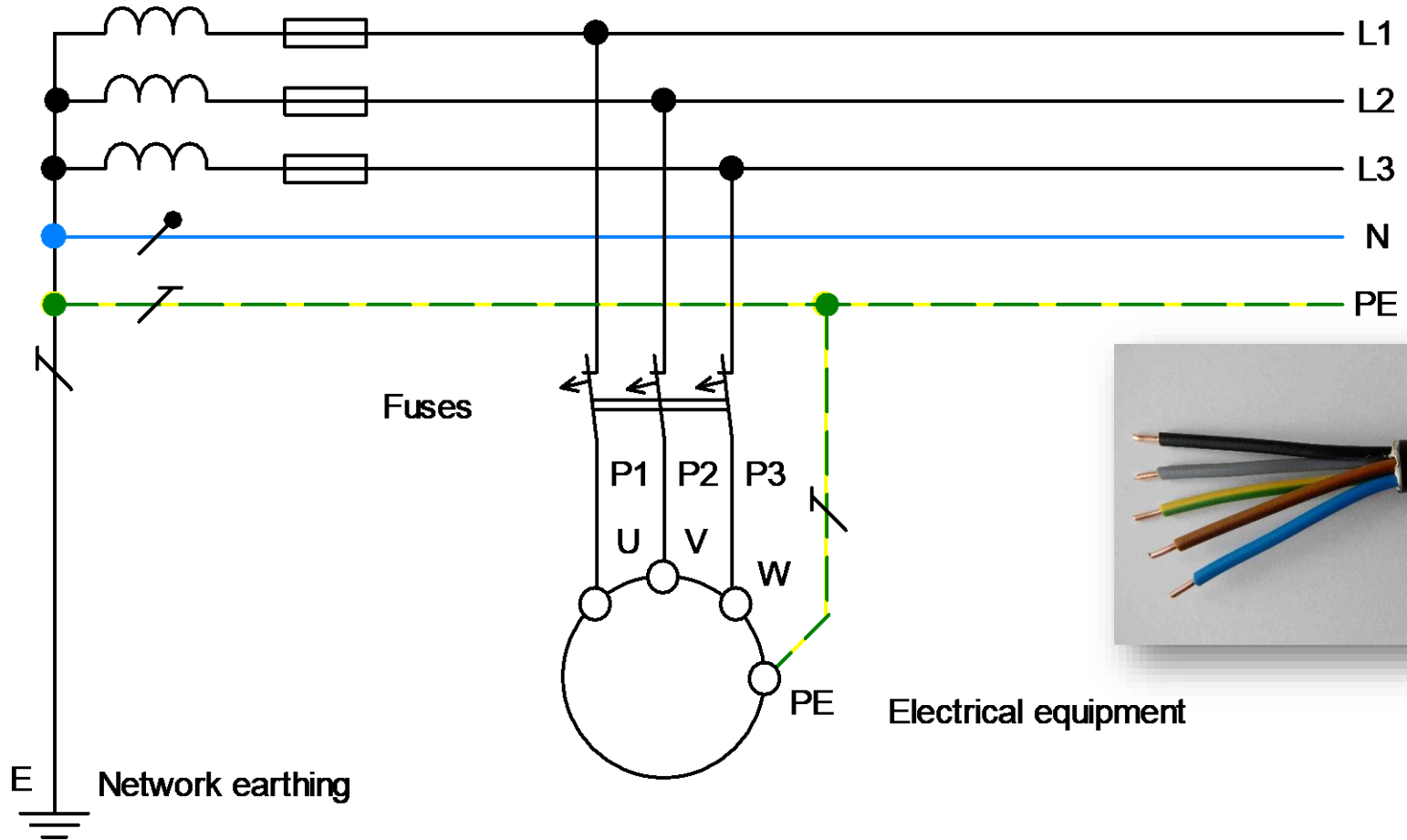


PEN conductor

Bare buses

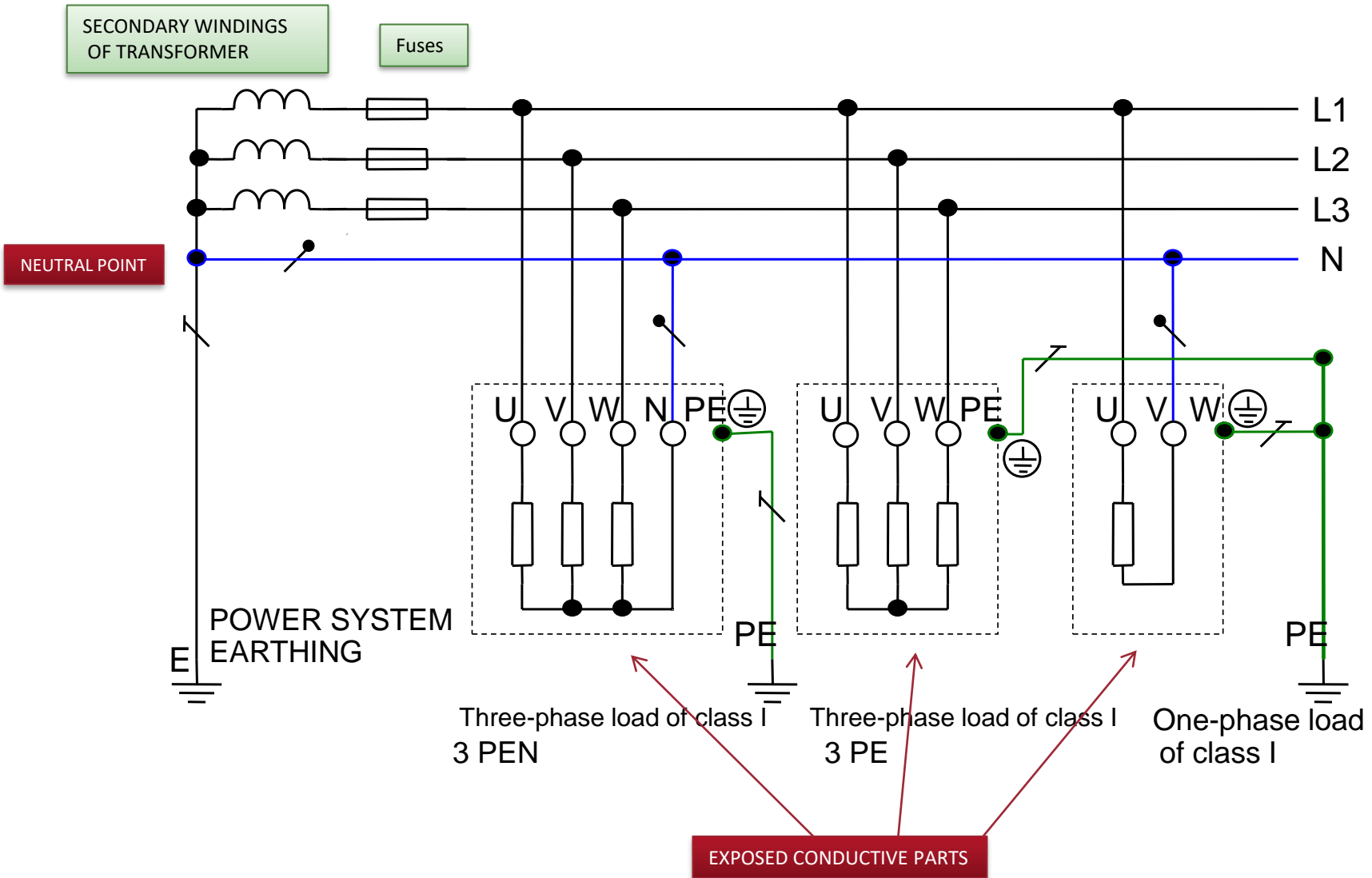


PE and N bridge



Electrical equipment

## DIRECT ELECTRICAL CONNECTION OF THE EXPOSED PARTS TO EARTH

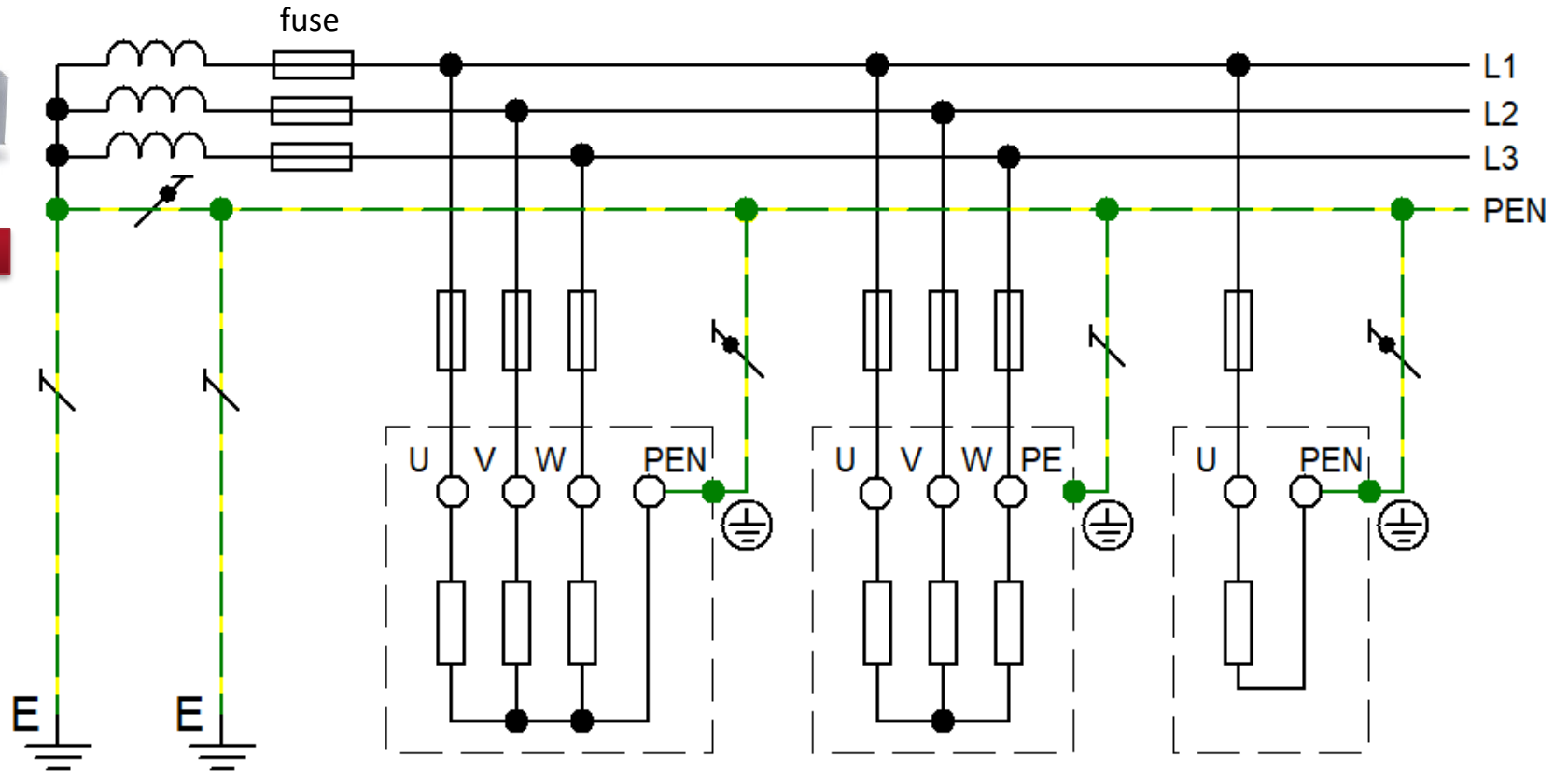


# TN-C SYSTEM

NEUTRAL AND PROTECTIVE FUNCTIONS ARE COMBINED IN ONE WIRE



NEUTRAL POINT



Power system earth

Grounding distribution networks

Three-phase load class I  
3 PEN

Three-phase load class I  
3 PEN

One-phase load class I  
1 PEN

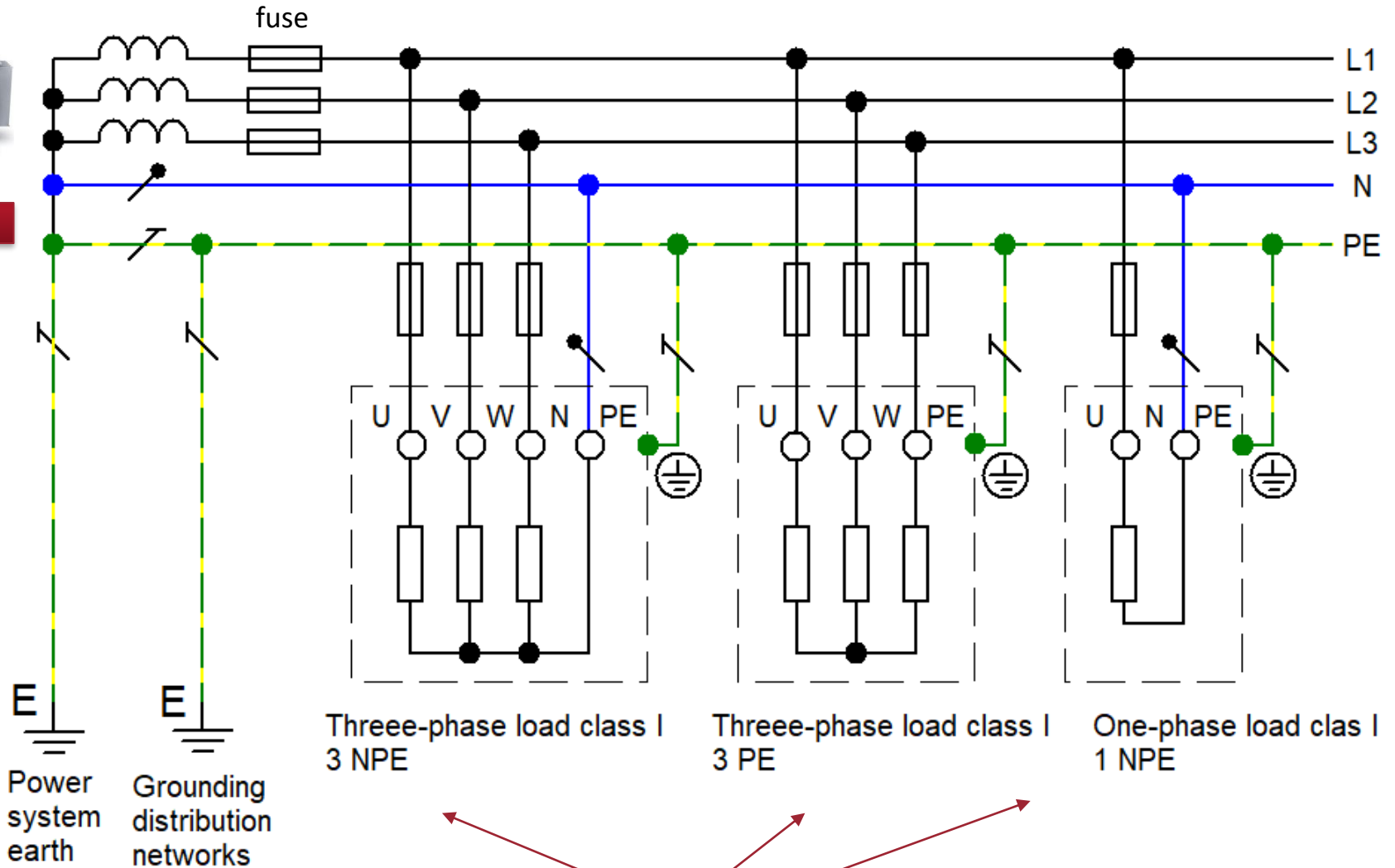
EXPOSED CONDUCTIVE PARTS

# TN-S SYSTEM

## SEPARATE NEUTRAL AND PROTECTIVE CONDUCTORS

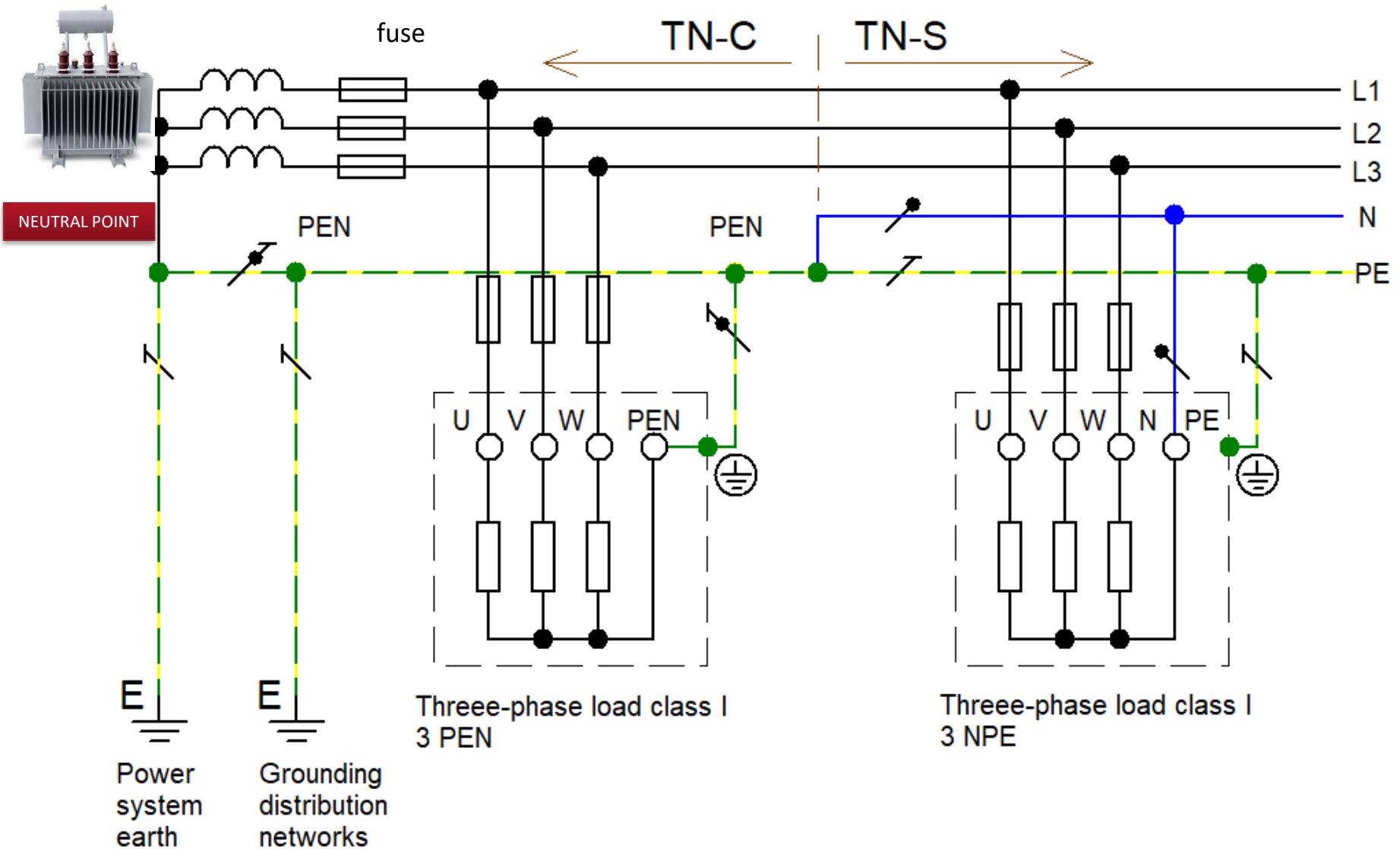


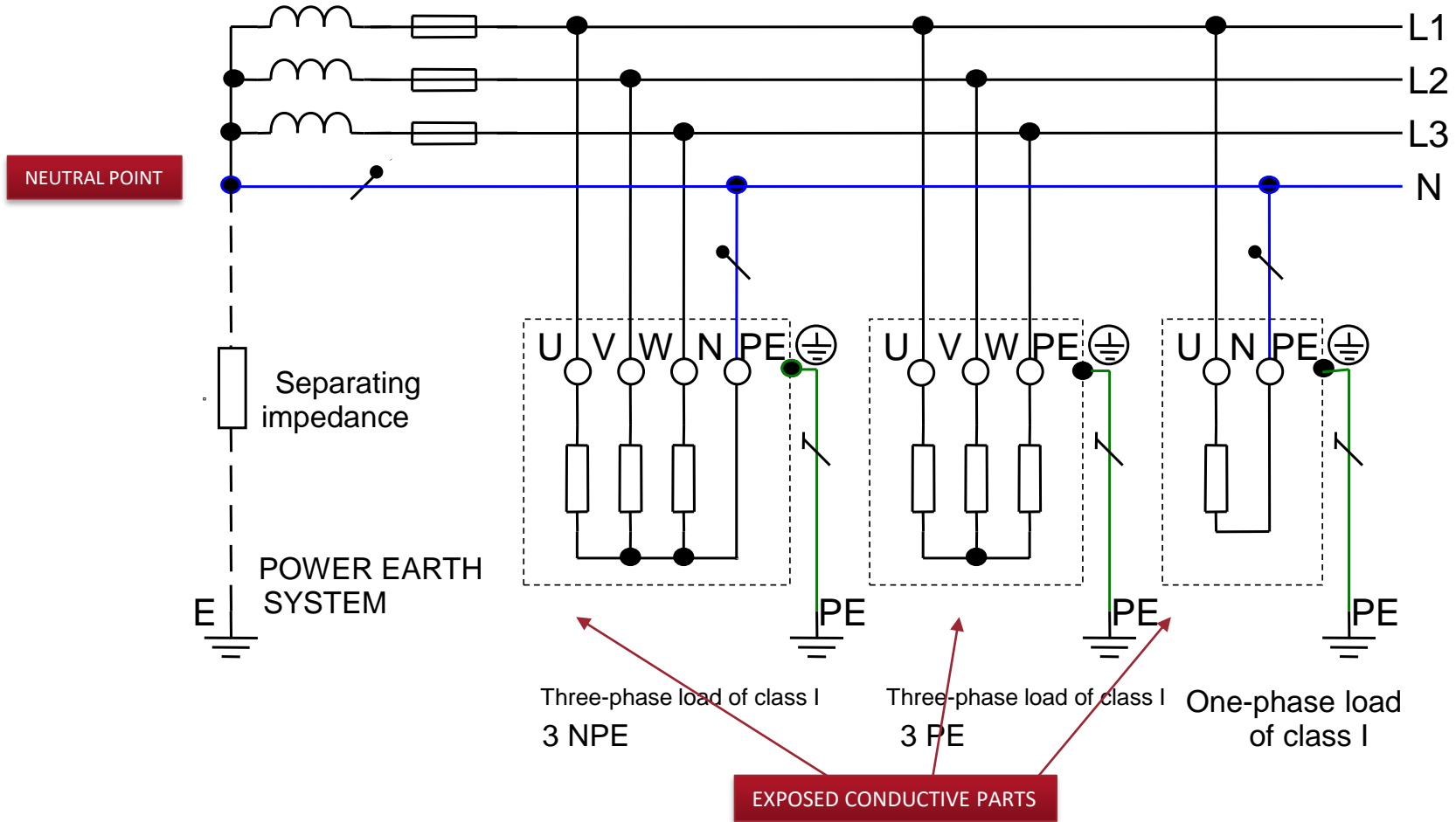
NEUTRAL POINT

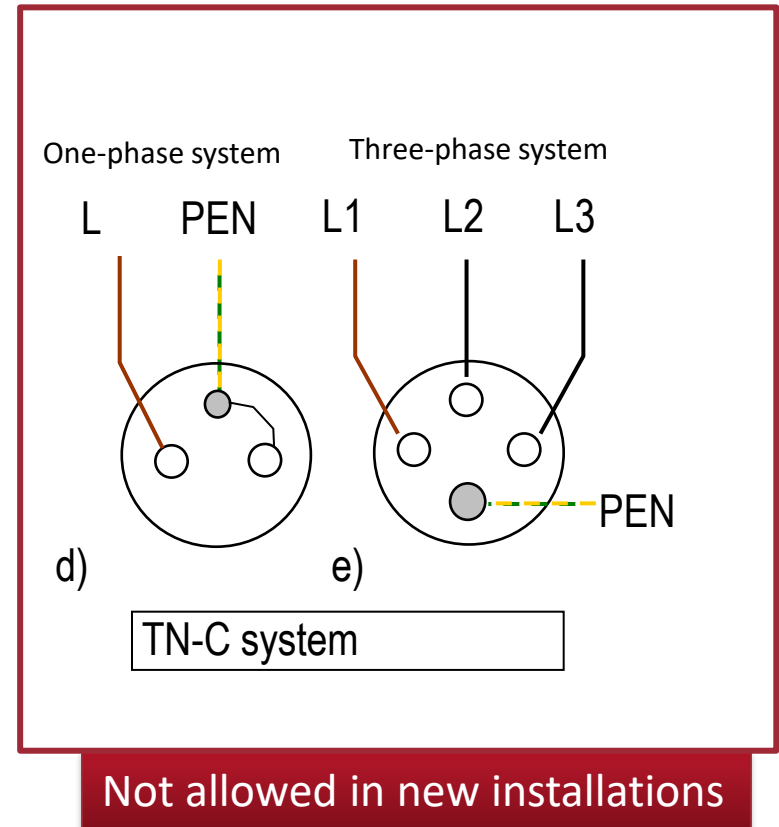
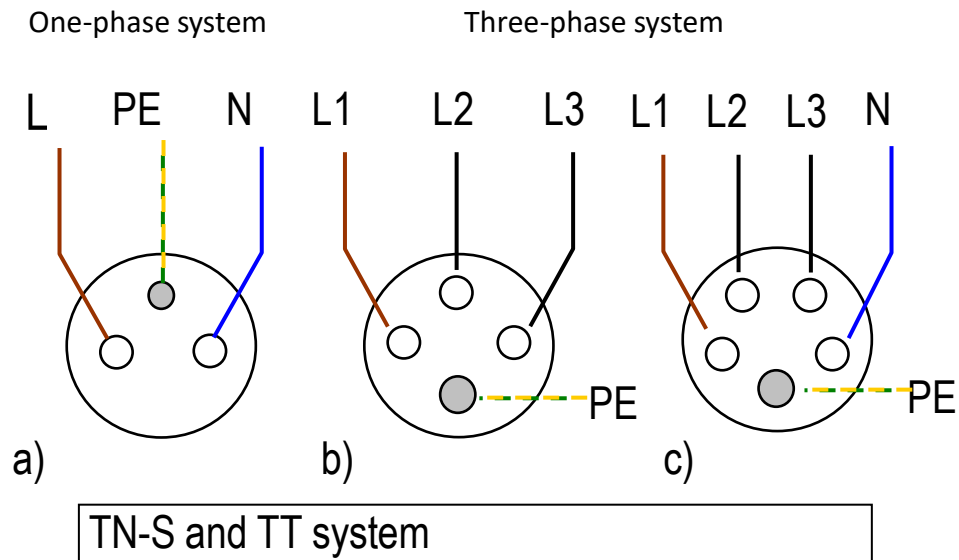


EXPOSED CONDUCTIVE PARTS

# TN-C-S SYSTEM COMBINED SYSTEM









- Is a professionally qualified person - **instructed** in the **regulations to ensure occupational safety and health for work** on and near electrical equipment,
- Familiar with **first aid** procedures for electrical shock.
- **No electrical engineering degree is required.**
- In particular, the instructed person shall:
  - **independent operation of the EE** without voltage limitation, with the restriction that it can only touch those parts of the equipment that are intended for operation,
  - work **according to the instructions** on and near **EE of ELV and LV** without voltage,
  - work **with supervision** on and near **EE of HV**, without voltage,
  - work under the **supervision of a knowledgeable person in the vicinity of uncovered live parts** with voltage

- A person with a professional qualification (education) who, after training, has passed an examination of professional competence to perform activities in electrical engineering in the specified scope.
- Must have professional experience according to the organization's regulations and first aid training.
- **Shall perform activities on and near the EE independently, except in special cases based on risk assessment.**
- Verification of knowledge by examination shall be carried out by a three-member examination committee, the chairman of which shall be a revision engineer.

- Safety message
- Protective and work equipment
- Technical and organisational measures



**Prohibition signs (Do not do)**  
Signs prohibiting certain behaviour  
e.g. No Smoking



**Warning signs (Caution, Danger)**  
Signs which indicate a specific course of action  
is to be followed  
e.g. Danger high voltage



**Mandatory signs (You must do)**  
Signs which indicate a specific course of action  
is to be followed  
e.g. Safety helmets must be worn



**Safe Condition Signs (Safest way)**  
Signs giving information about safe conditions,  
doors, exits and escape routes  
e.g. Fire exits



**Fire signs (Fire fighting equipment)**  
Signs indicating the location of  
fire fighting equipment  
e.g. Fire point

## Example



**Danger**  
Electrical room



**No storage  
permitted**

- **Protective equipment**

- Insulating gloves, boots and carpets
- Insulating helmets and suits
- Protective goggles and shields
- Short-circuiting, Discharging and Earthing Equipment ...



- **Working aids**

- Testers, measuring instruments
- Insulated tools, ladders ...



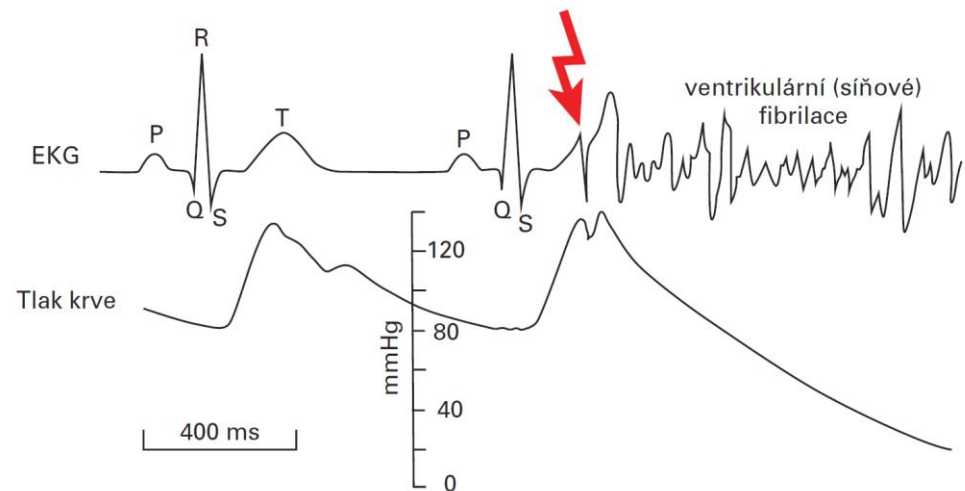
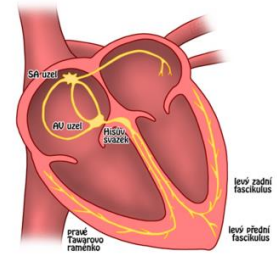
1. Student in school laboratories may work only under the supervision of a qualified person (teacher).
2. All students must be instructed in the safety requirements, safety rules and laboratory instructions applicable to their work.
3. The student shall be equipped with and use appropriate tools, measuring and testing devices and individual protective equipment, which shall be maintained in a good condition.
4. All student shall be provided with training and information so that able to give appropriate first aid treatment for electric shock.
5. School laboratory shall be provided with means for emergency switching off (Central Stop), first aid kit, and fire extinguisher.
6. During any work adequate signs shall be displayed to draw attention to any relevant hazard.



- The hazard primarily **depends on the value of current** passing through human body or on other effects caused electric or electromagnetic field.
- Important parameters regarding the risk of electric shock:
  - Value and way of current through body
  - Time duration of current
  - Kind of current (DC, AC - frequency)
  - Phase of cardiac cycle
  - Individual health stage of person

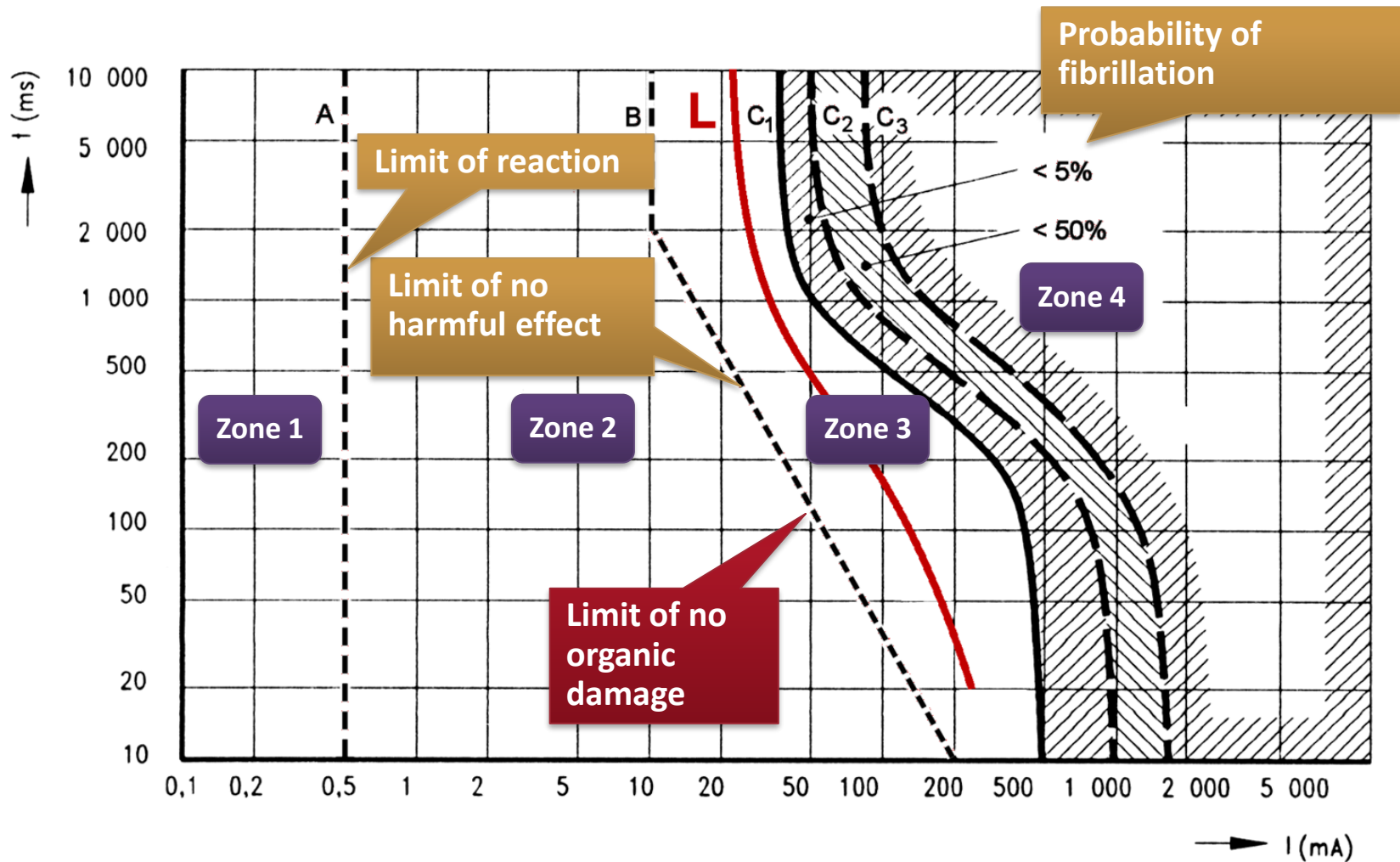
- Currents of **10 to 30 mA** do not usually lead to death, but prolonged exposure causes muscle spasms, breathing difficulties, etc.
- Currents **above 30 mA** can be fatal if not disconnected quickly.
- Currents **up to 500 mA** will cause death if they pass for more than about 0.5 s
- Currents **above 500 mA** are usually lethal even with short transit times.
- **Ventricular fibrillation** occurs at currents above 500 mA, or at prolonged currents as low as 50 mA. It is considered the leading cause of death in electrocution.

PŘEVODNÍ SYSTÉM SRDEČNÍ



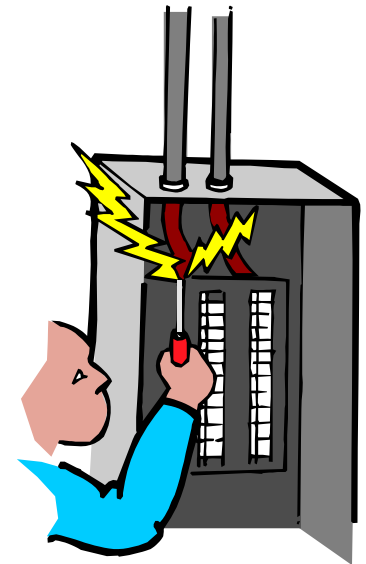


# TIME/CURRENT ZONES OF EFFECT OF A.C. CURRENTS ON PERSONS (IEC 479-1)

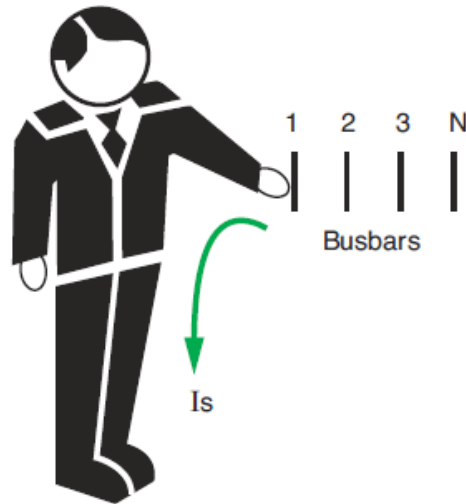


This diagram is valid for AC 15-100 Hz , way of current left hand to both legs

- **Live parts**  
designed to conduct electrical current (or have conductive connection to them).
- **Exposed conductive parts**  
not designed to conduct current, can be touched, are not normally non-live, but can become live when basic insulation fails.
- **Non-live parts, dead parts.**

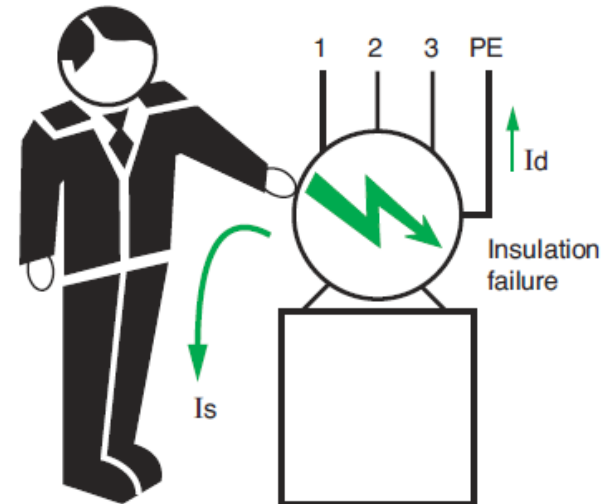


Hazardous live part  
(Direct contact with dangerous live part)



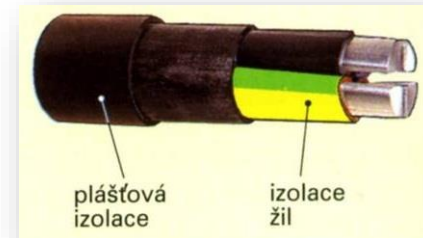
$I_s$ : Touch current

Exposed conductive part  
(Indirect contact with exposed conductive part after insulation)



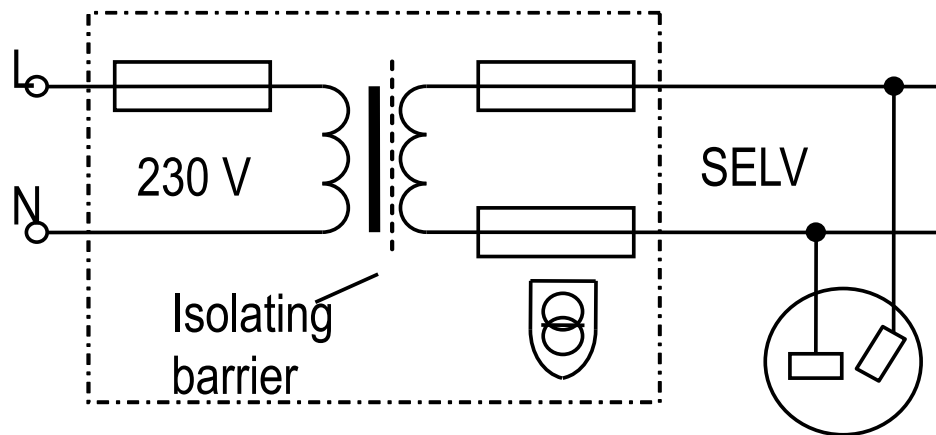
$I_d$ : Insulation fault current

- Basic insulation
- Enclosures
- Obstacles
- By placing out of reach

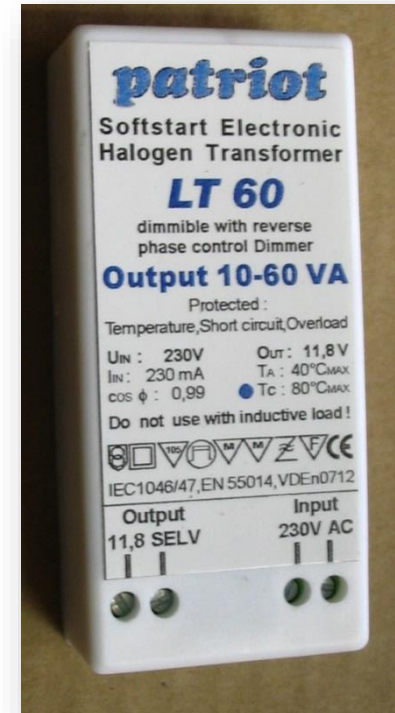


## SELV (Safety Extra Low Voltage)

- Max. 50 VAC, 120 V=
- Independent supply or supply with isolating barrier
- Separation from other circuits (level as doubled insulation)
- Non-interchangeable plugs and sockets without protective contacts
- Any part of circuit is not connected with earth or any part of other circuits



Transformer SELV Uninterchangeable socket



# DEGREES OF PROTECTION PROVIDED BY ENCLOSURES

## IP CODE - INGRESS PROTECTION MARKING (EN 60529)

IP XX(X)

| Level | Effective against | Description  |
|-------|-------------------|--|
| 0     | -                 | No protection against contact and ingress of objects   |
| 1 (A) | >50 mm            | Any large surface of the body, such as the back of a hand, but no protection against deliberate contact with a body part                               |
| 2 (B) | >12.5 mm          | Fingers or similar objects   |
| 3 (C) | >2.5 mm           | Tools, thick wires, etc.   |
| 4 (D) | >1 mm             | Most wires, slender screws, large ants etc.  |
| 5     | Dust protected    | Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment. |
| 6     | Dust tight        | No ingress of dust; complete protection against contact (dust tight). A vacuum must be applied. Test duration of up to 8 hours based on air flow       |

| Level | Protection against                | Effective against  |
|-------|-----------------------------------|--|
| 0     | None                              | -  |
| 1     | Dripping water                    | Dripping water (vertically falling drops) shall have no harmful effect on the specimen   |
| 2     | Dripping water when tilted at 15° | Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle of 15° from its normal position  |
| 3     | Spraying water                    | Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect   |
| 4     | Splashing of water                | Water splashing against the enclosure from any direction shall have no harmful effect  |
| 5     | Water jets                        | Water projected by a nozzle (6.3 mm) against enclosure from any direction shall have no harmful effects  |
| 6     | Powerful water jets               | Water projected in powerful jets (12.5 mm nozzle) against the enclosure from any direction shall have no harmful effects   |
| 7     | Immersion, up to 1 m depth        | Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).  |
| 8     | Immersion, 1 m or more depth      | The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects. |
| 9     | jetting high-pressure hot water   | high-pressure, high-temperature water jetting from any direction against the enclosure must not cause any damage   |



Socket IP 2X



Socket IP 44

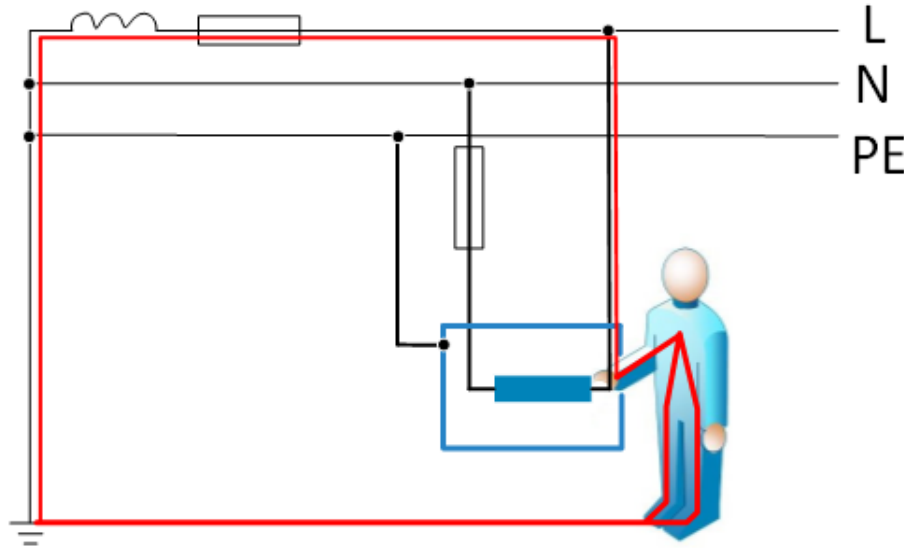


Socket IP 55



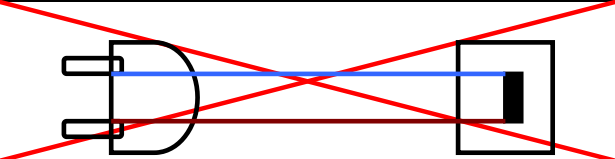

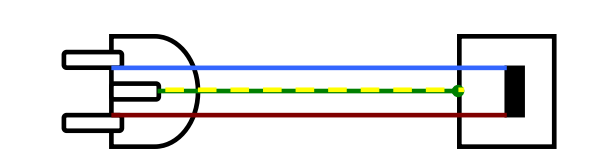
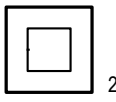
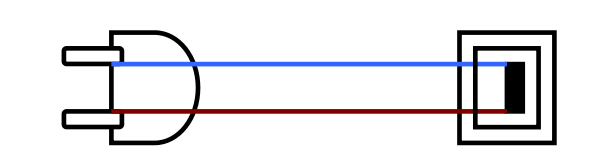

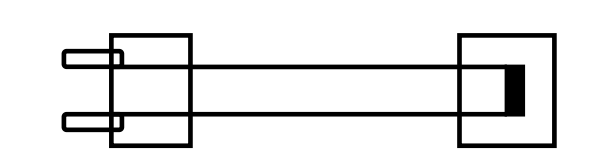
Socket IP 66

# SAFE LOW VOLTAGE (ELV) LIMITS (CSN 33 2000-4-41 ED.3)



| Environment     | Basic protection            | Effective AC ( $V_{ef}$ ) | DC (V) |
|-----------------|-----------------------------|---------------------------|--------|
| Dry             | Insulation, baffles, covers | 50                        | 120    |
|                 | not necessary               | 25                        | 60     |
| Other (wet)     | not necessary               | 12                        | 30     |
| When submerged. | Insulation, baffles, covers |                           |        |



| Class | Symbol   | Principle of protection  | Comment  |
|-------|--|--|--|
| 0     |  |  | Without protective system.<br>Not allowed in Czech republic. |
| I     |  1) |  | Connection of exposed parts with<br>protective earthing.     |
| II    |  2) |  | Double or reinforced insulation                              |
| III   |  2) |  | Socket must be unchangeable.<br>Supplied from SELV.          |





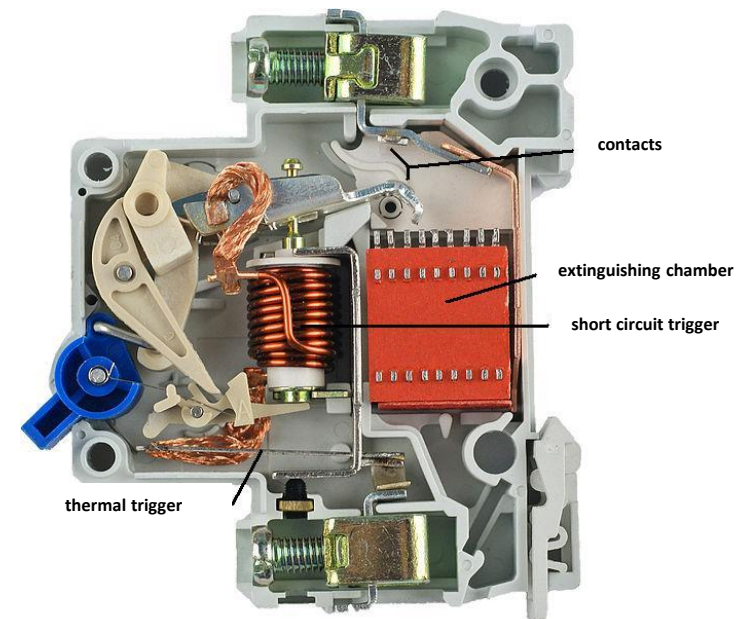
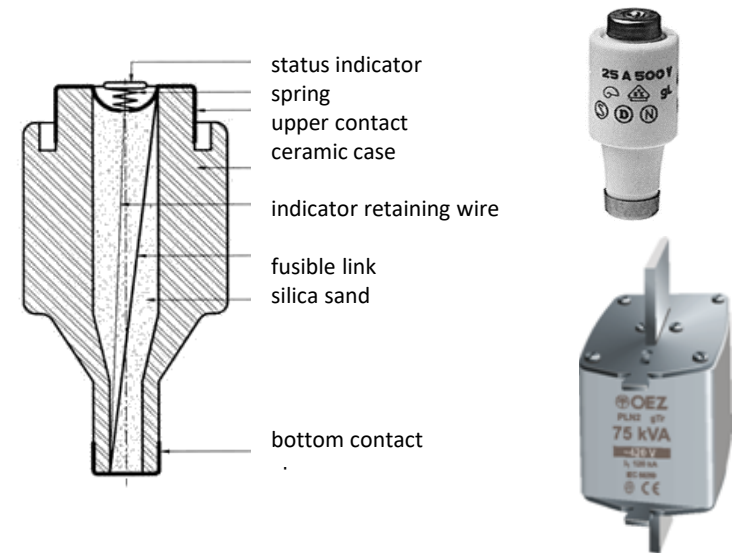


## Fuse

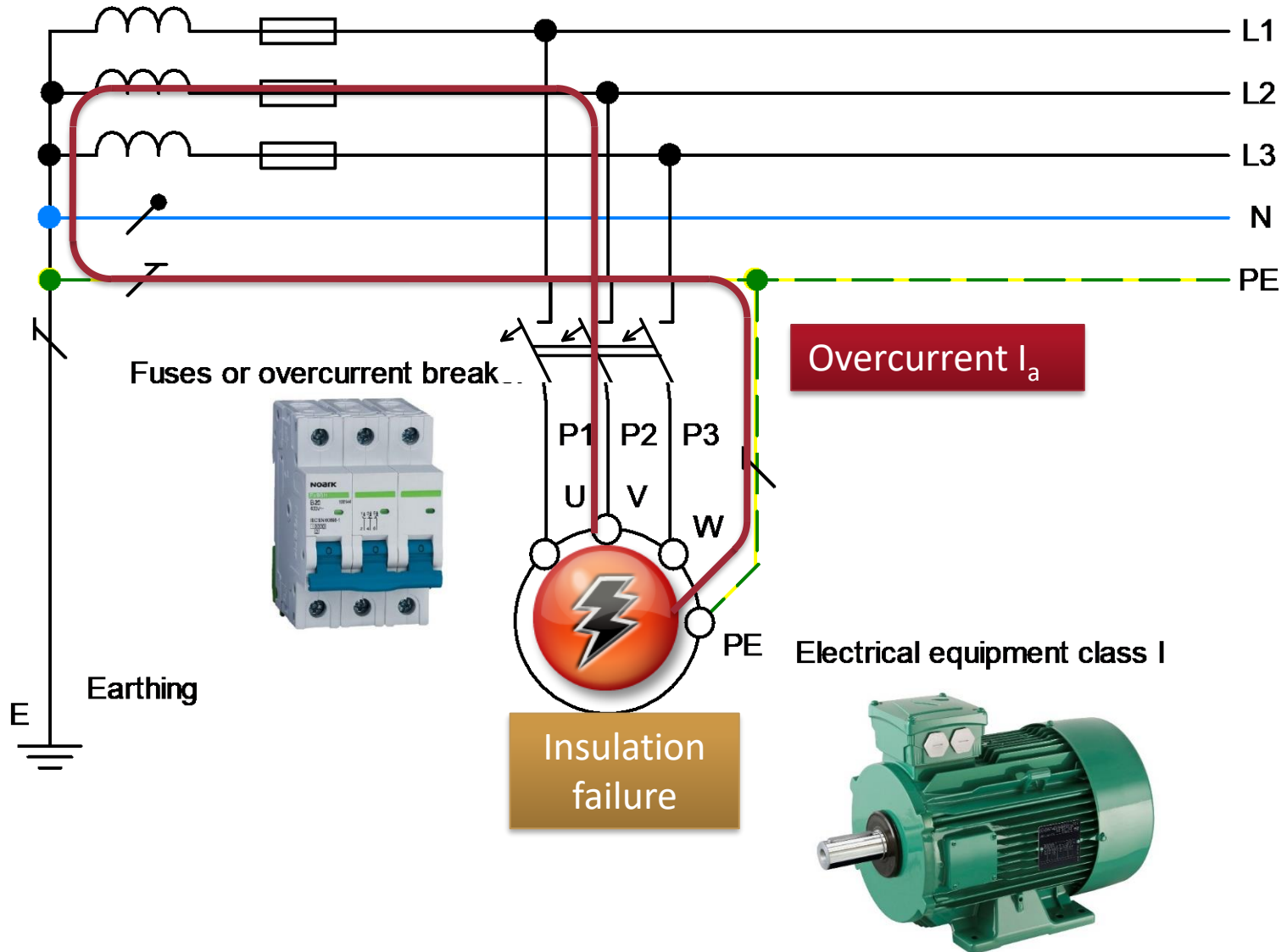
- Artificial weakest point of an electrical circuit
- It is destroyed by the shutdown and **must be replaced**

## Circuit breaker

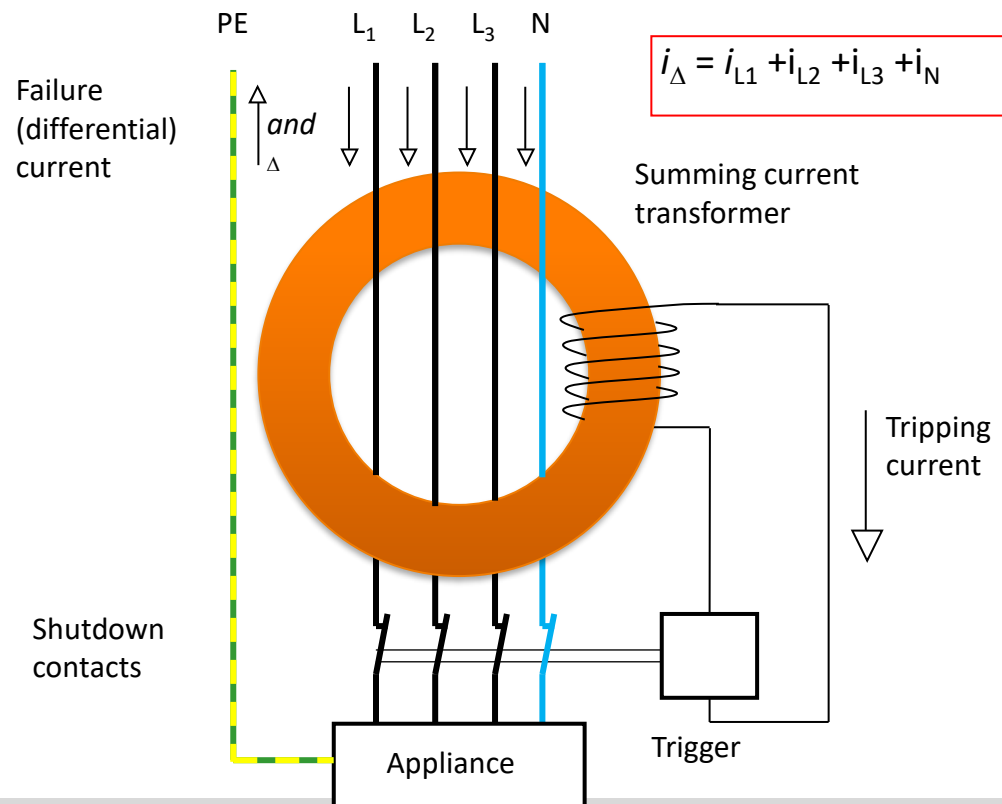
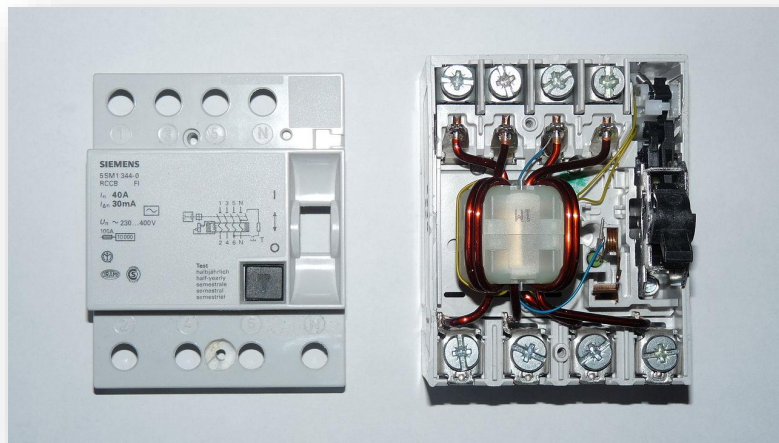
- **Can be switched on again** after switching off
- Includes overcurrent and short circuit trigger



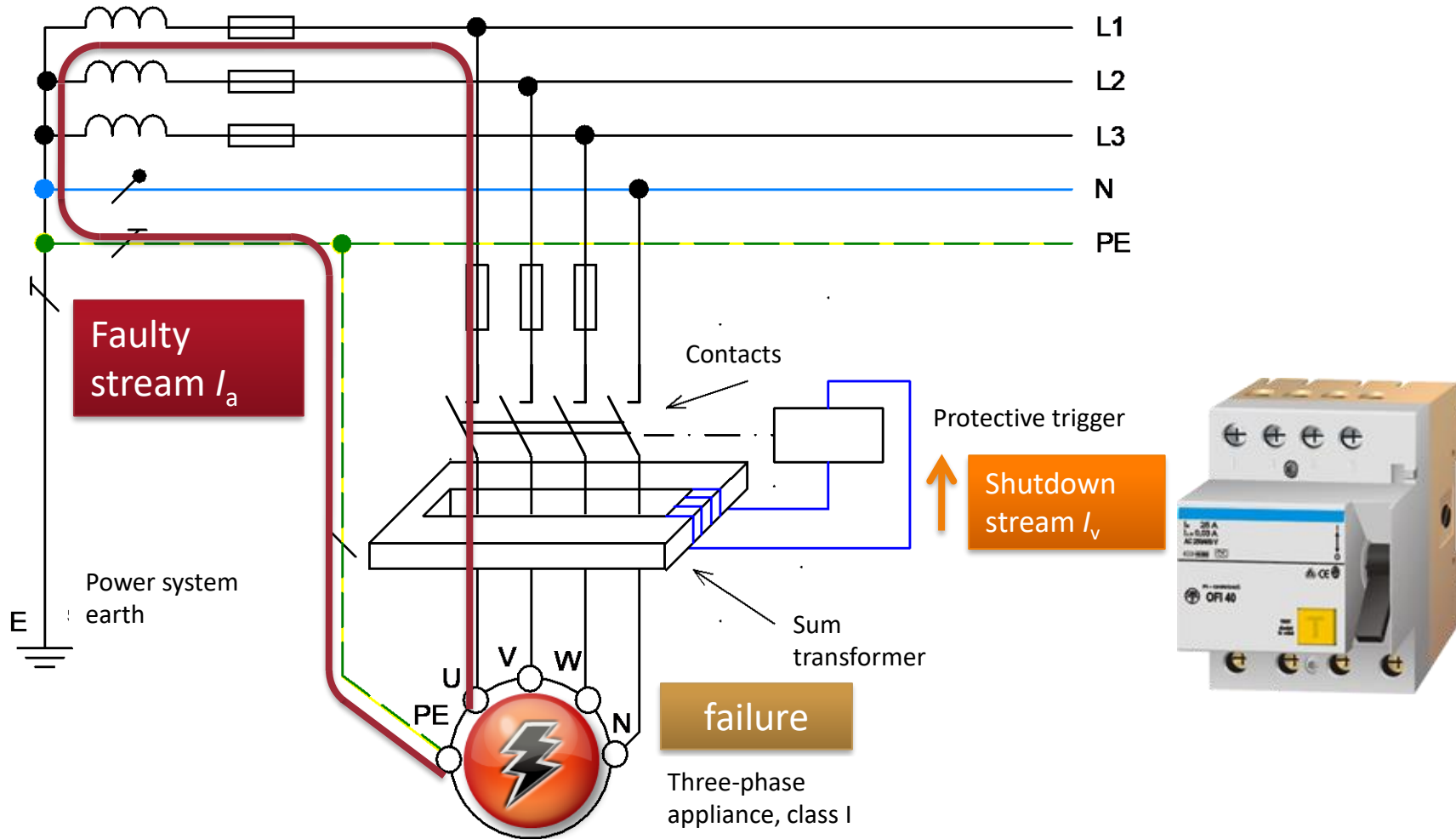
# PROTECTION BY AUTOMATIC DISCONNECTION IN TN-S SYSTEM



- RCD – residual current device, switches off when the magnitude of the **differential current**  $I_{\Delta}$  exceeds nominal value  $I_{\Delta n}$
- Does not protect against overcurrents
- It is very sensitive ( $I_{\Delta n} = 10 \text{ mA to } 500 \text{ mA}$ )

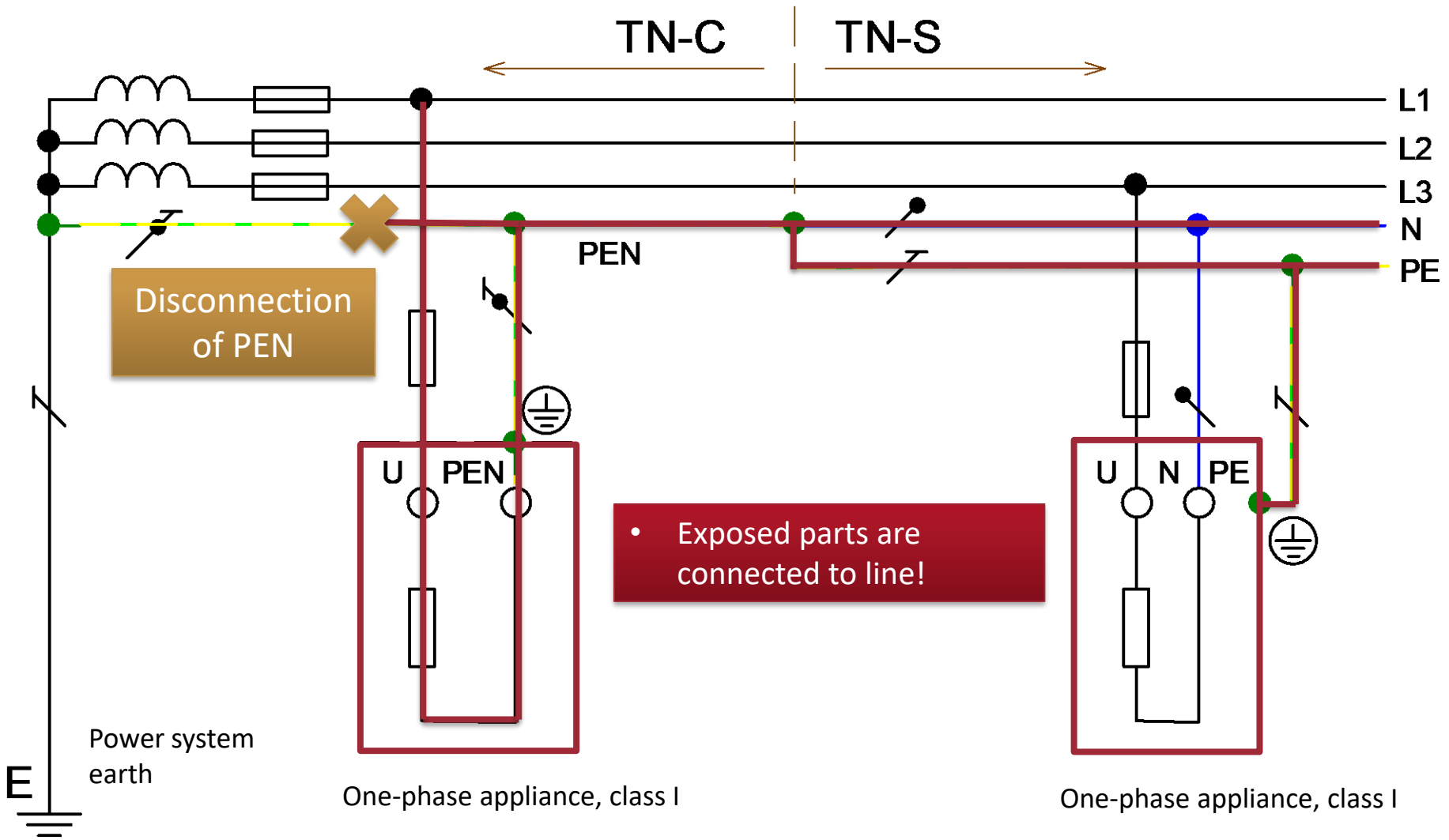


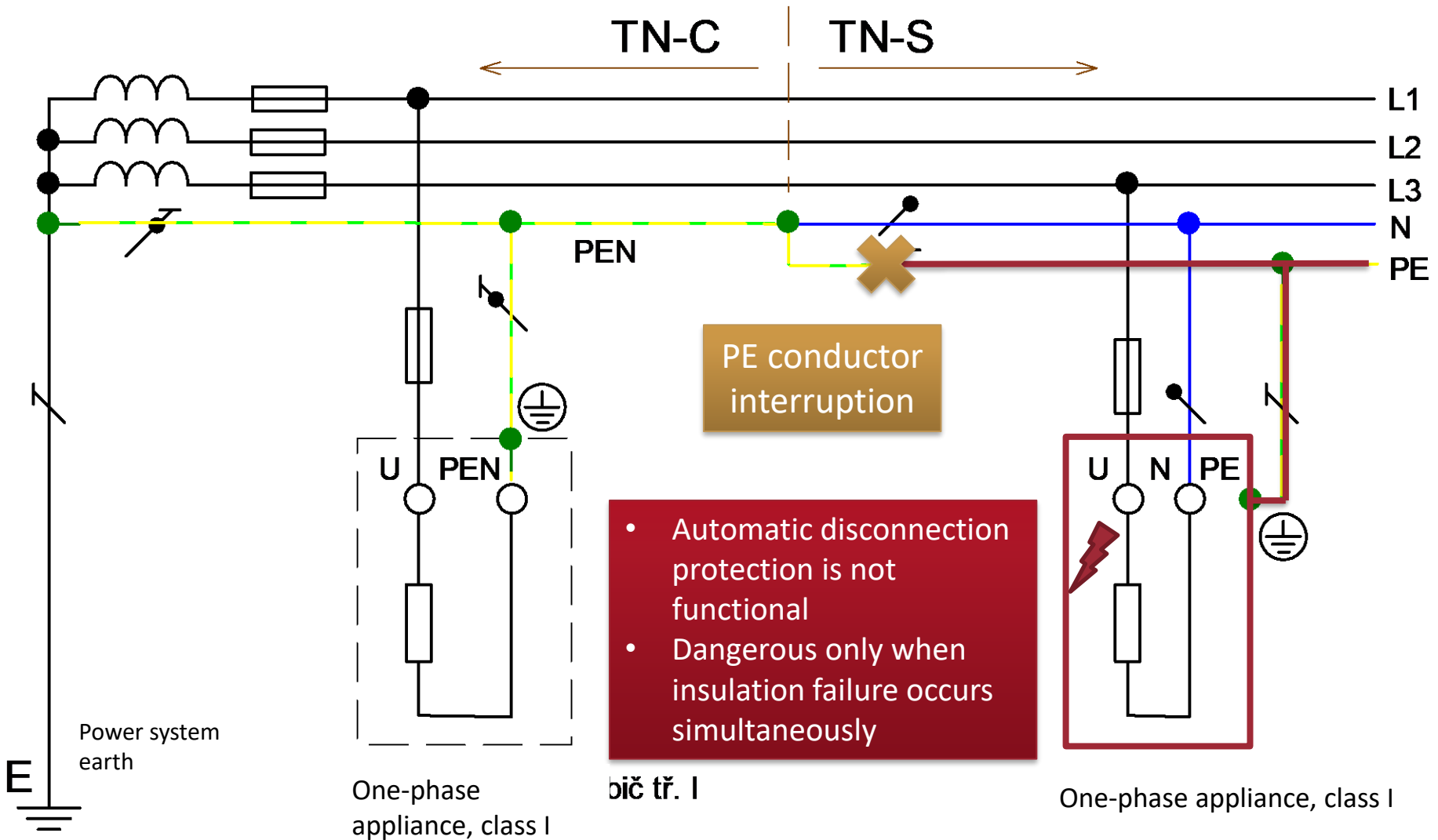
# PROTECTION BY RCD IN TN-S NETWORK



- A small fault current (typically 30 mA) is sufficient for switching off within 0.4 s
- There is no destructive failure of the device



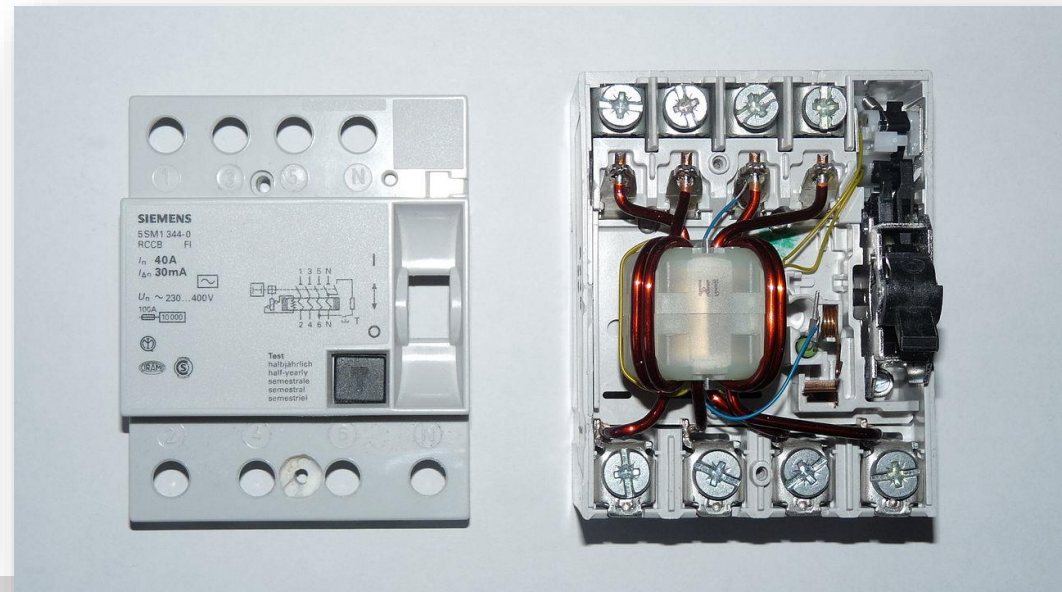
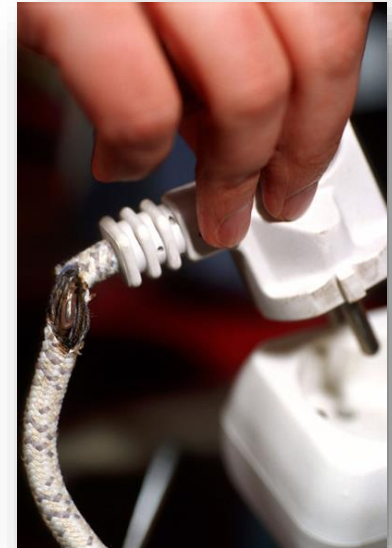


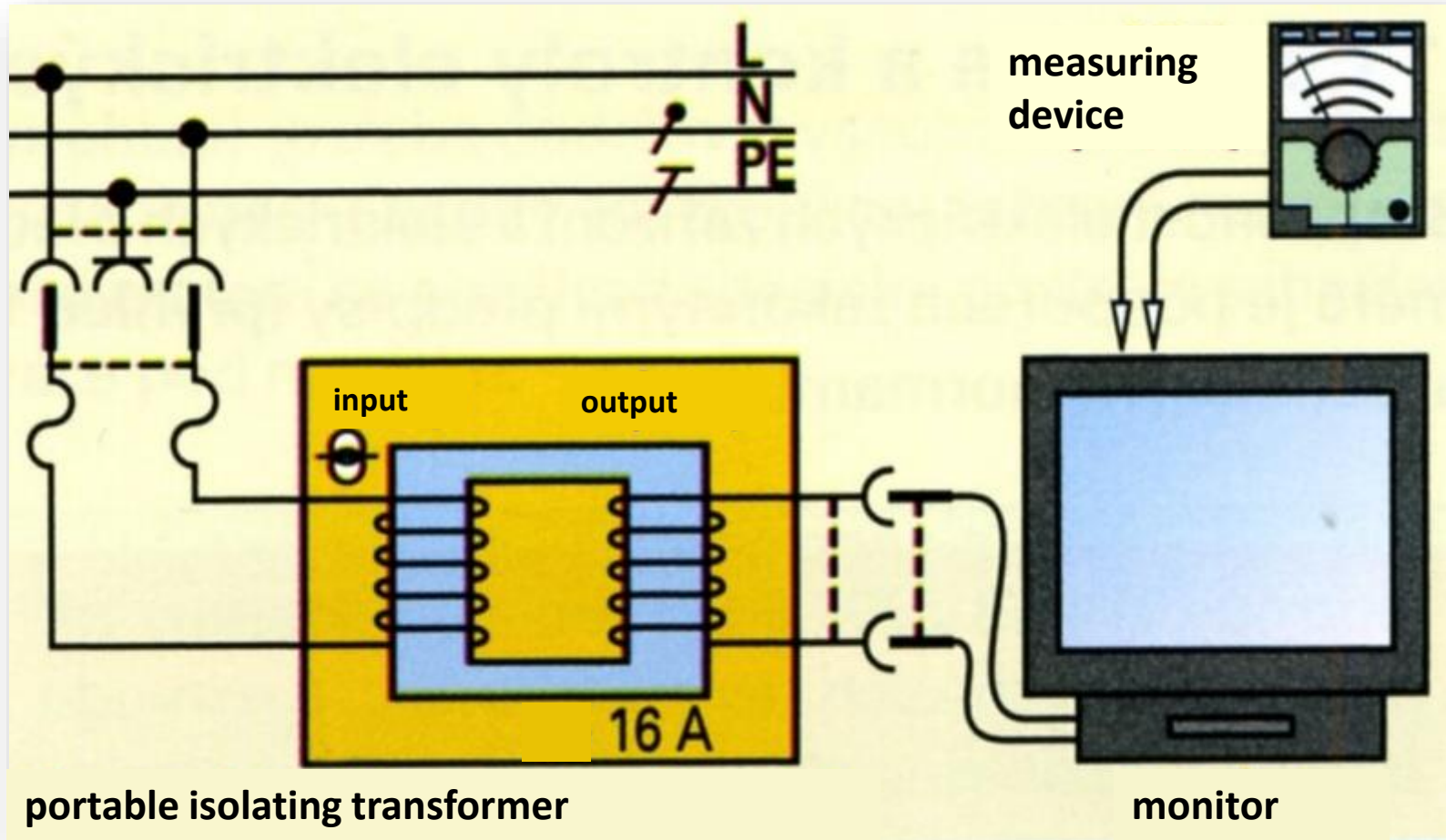


## Mandatory use of a RCD as additional protection:

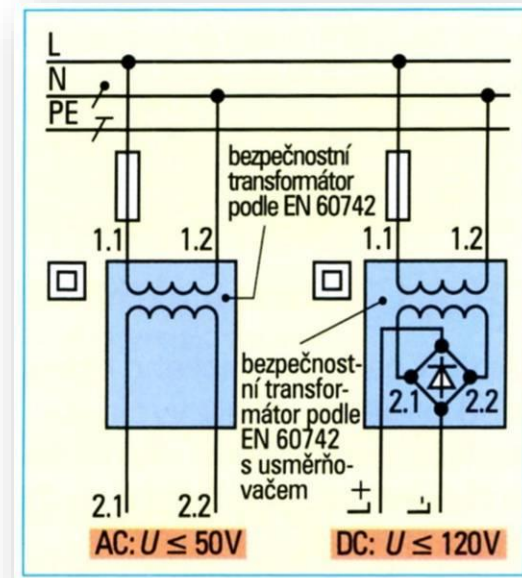
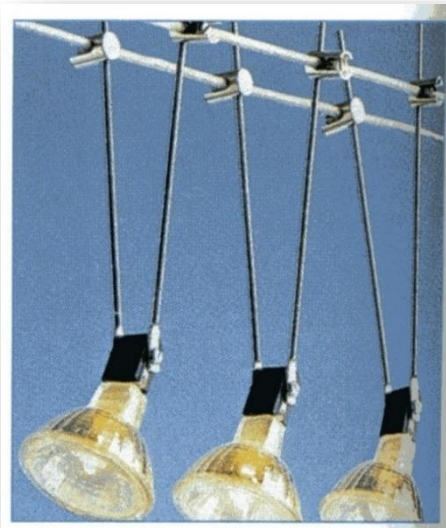
According to CSN 33 2000-4-41 ed. 3, it is necessary to use RCD with  $I_{\Delta n} \leq 30 \text{ mA}$

- for general-purpose sockets used by the general public with a rated current up to 32 A (there are exceptions)
- for lighting circuits in households
- mobile devices with rated current up to 32 A
- rooms with bath or shower (exception - water heater)
- electrical installation of swimming pools and fountains
- electric floor and ceiling heating systems





- Independent or isolation barrier sources
- **Separation from other circuits** at the double insulation level
- **Non-interchangeable sockets and plugs without protective contacts**
- No part of the circuit **shall be connected to earth** or to parts of other circuits
- **When the voltage is less than 25 V $\sim$  or 60 V $=$ , basic protection may not be implemented** (In humid environments, the limit is 12 V $\sim$  or 30 V $=$ .)



- First aid is defined as a set of simple and effective measures which, in the event of a sudden threat or impairment to health or life, deliberately and effectively limit the extent and consequences of the damage.
- This is care given to the person affected before the arrival of the ambulance service or other qualified worker.
- It is the moral duty of every person to provide first aid.

### **Objectives of the aid:**

- To save a life
- Prevent deterioration of health
- Arrange professional treatment (call the ambulance)

- Bleeding
  - Possibility of exsanguination within 2 minutes (within 1 minute for large arteries)
  - Life-threatening is the loss from 1 l of blood in an adult
- Respiratory (and circulatory) arrest
  - Death in 3-5 minutes,
  - As a result of brain death
- Unconscious
  - Death threatened in 15 minutes
  - Danger of tongue entanglement, choking on blood or saliva...
- Burns
  - Burn > 15% of body surface is threatening (>10% for children and the elderly)
- Trauma
- Shock



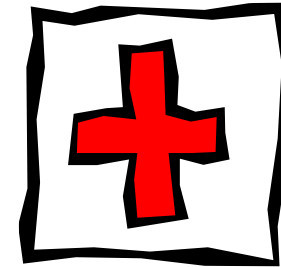
last moments before death

- Burns of skin and internal organs
- Great convulsions leading to fractures of bones
- Heart fibrillation
- Stop of breathing
  
- Secondary hurt - bleeding, fractured bones (after falling down)



- **Technical first aid**

- interruption of the injury process
- the release of the injured



- **Determination of the extent of injury**

- consciousness and vital functions
- other serious injuries



- **Call for medical assistance**



- **Providing lay first aid**



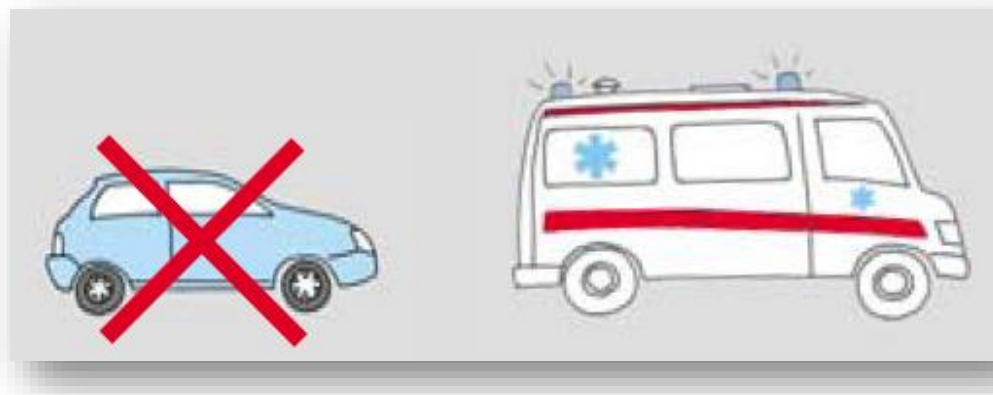
- Incidence of severe bleeding
  - If we see bleeding, it means the **circulation is fine**.
  - We have to **stop the bleeding** (otherwise the circulation won't be fine for long).
- State of consciousness
  - If the **sufferer is responsive**, **circulation and breathing** are fine.
  - If the **casualty is unresponsive**, we need to **determine the respiratory status**.
- Respiratory status
  - If **the person is conscious but not breathing well**, the vital signs are still relatively fine, but there **is an imminent risk of failure**.
  - If the injured person is "unconscious" (unresponsive) but **breathing normally** (even on repeated checking), the **circulation is fine**.
  - If **the casualty is "unconscious"** (unresponsive) and **not breathing normally** (or even **not breathing at all**), the casualty's vital signs have failed and they are in **a state of "clinical death" - we start CPR**.
- **Palpation of the pulse is NOT part of the initial diagnosis and we do not use it.**

- National emergency number **155**
  - Medical Rescue Service of the Czech Republic
- European emergency number **112**
  - Integrated Rescue Service
  - **they know foreign languages** (English, German)
  - Emergency calls in EU countries
  - Can locate the caller (landline exactly, mobile about 300 m)
  - Works without a SIM card
- Mobile app „Zachranka“
- Mountain service 1210
- Arrival within 20 min.



## Conscious:

- We do not let the injured person get up, walk, smoke, etc.
- We don't serve liquids
- We protect him from hypothermia
- Do not leave the injured person and repeatedly check the state of consciousness (e.g. by addressing)
- We don't transport them, but we always call for medical help



## Unconscious:

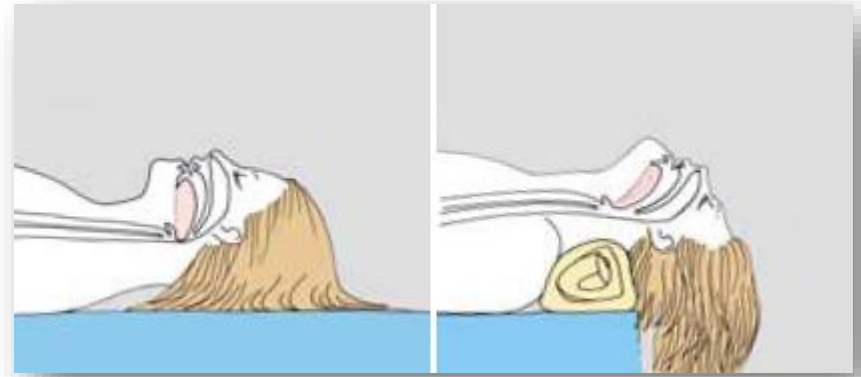
- We do not relocate the injured person unless is threatened by the environment
- Loosen the garment around the neck, chest and waist
- Placement in a stable (recovery) position only if necessary (treatment of multiple wounded)



## Breathlessness:

- In the absence of breathlessness, **we automatically assume cardiac arrest!**
- We do not relocate the victim unless he or the rescuer is threatened by the environment.
- We don't dwell on treating non-life-threatening injuries.
- Immediately clear the airway and begin cardiopulmonary resuscitation.

- Lay the casualty **flat on his back** on a firm mat.
- Remove **visible obstructions** in his mouth.
- **Bow the head** of the injured person .



- Check for spontaneous breathing.
- If the casualty is not breathing, **start CPR.**

- We find the imaginary connection between the nipples.
- With both hands extended, continuously compress the sternum to a depth of **4 to 5 cm** at a rate of about **100 to 120 compressions per minute**.
- For children, the depth of compression is smaller.





- For children, it starts with 5 breaths
- Next **30 chest compressions**
- Followed by **2 quick breaths**, closing the nasal passage with one hand while maintaining the head tilt
- Volume of inspiration according to the proportions of the injured person, adult about 500-600 ml
- We continue with another series 30:2
- Persons who are not trained may not perform artificial respiration (without prior training they may worsen the patient's condition)



**30:2**

An AED is a device that can be used by lay people:

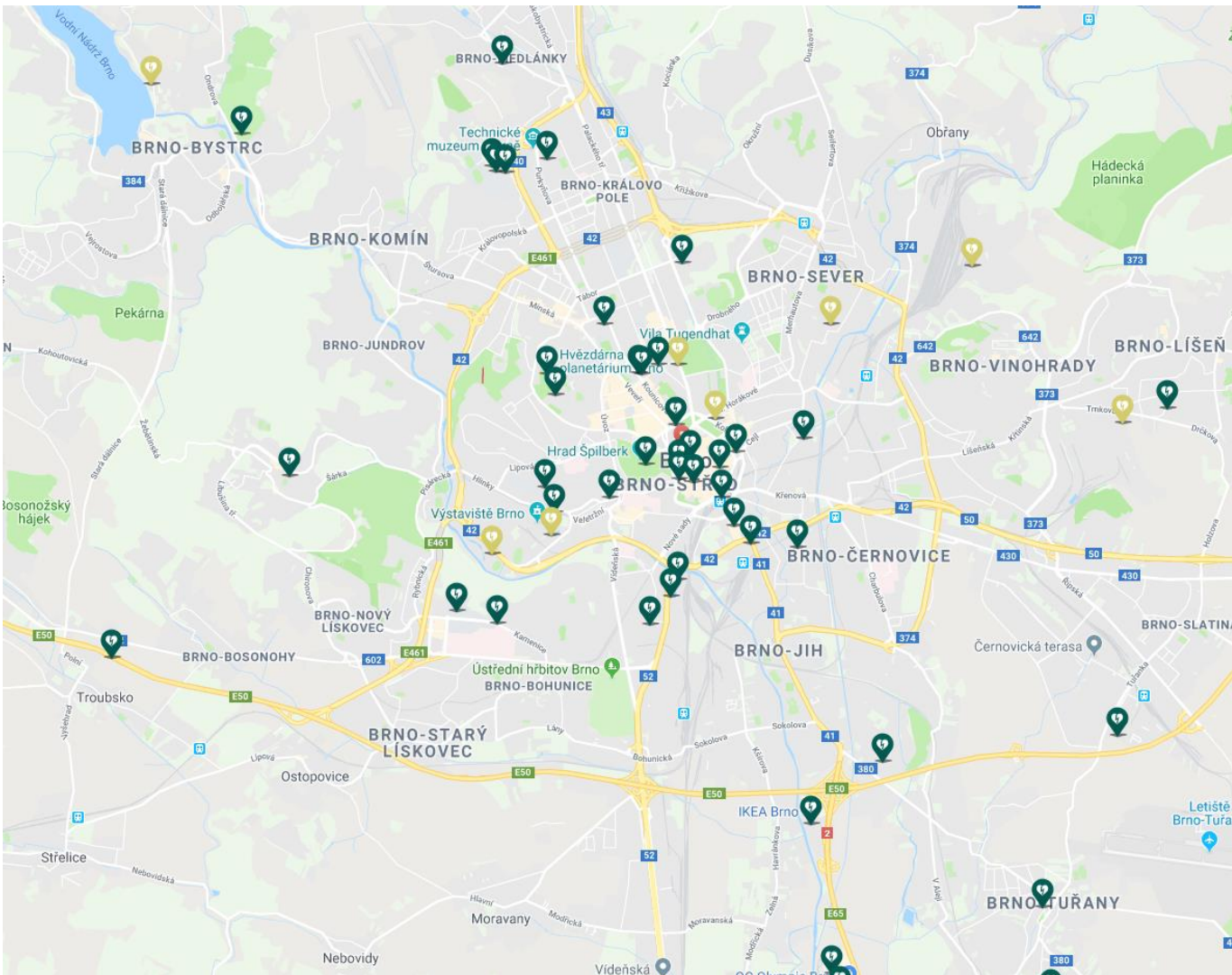
- can recognise the rhythm suitable for defibrillation
- allows defibrillation to be performed in a safe manner
- guides the user to action by voice and text instructions





- Intended for use by non-skilled person
- Voice guide for the whole CPR
- Non-interchangeable electrode system
- Check for correct massage with a sensor built into the electrodes
- Recording of the resuscitation process in memory with subsequent protocol

# LOCATION OF AEDs IN BRNO AND SOUTH MORAVIAN REGION



<http://www.zachrankaapp.cz/>



... and that's all

