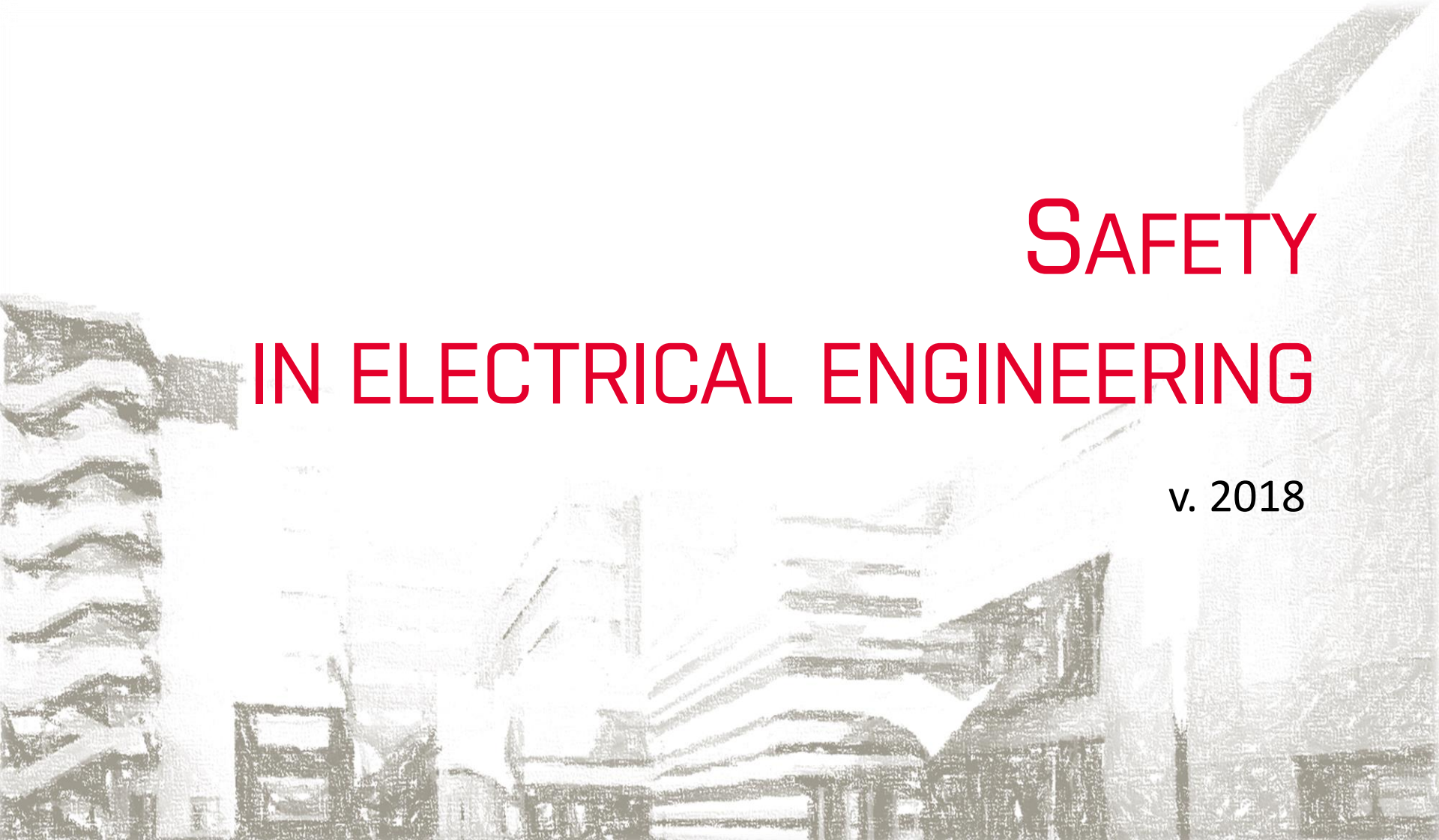
FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION

SAFETY
IN ELECTRICAL ENGINEERING

v. 2018



Safety of electrical equipment

Is ability of electrical equipment **not to be dangerous** by defined operating conditions for **persons , livestock, or property** and around area by effect caused electrical current or voltage or effect caused electrical function and **to protect against dangerous non-electric effect,** which should be by electrical equipment malfunction caused.

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

TYPES OF EE REGARD TO VOLTAGE (AC SUPPLY)

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

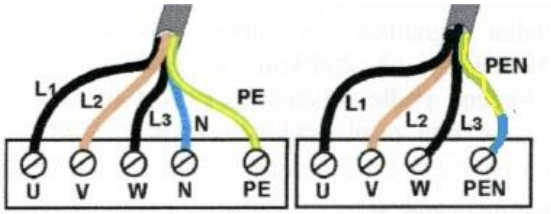
Nominal voltage of AC socket in CR: **230/400 V** (three phase system)

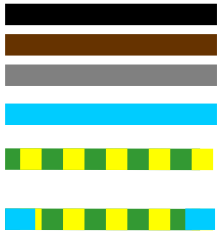
IDENTIFICATION OF CONDUCTORS AND TERMINALS (ČSN EN 60445 ED. 4)

Designation	Notation		Název	Označení	
	Conductor	Terminal		Vodič	Svorka
Střídavá soustava			**Zvláštní druhy vodičů a svorek**		
Phase	**L**	**U**	Protective earthing	**PE**	**PE**
1st phase	**L1**	**U**	Conductor with protective and neutral function	**PEN**	**PEN**
2nd phase	**L2**	**V**			
3rd phase	**L3**	**W**	Conductor with protective and mid-wire function	PEM	PEM
Neutral	**N**	**N**			
Stejnosměrná soustava			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

Colour identification of conductors (ČSN 33 0165 ed. 2)

- **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

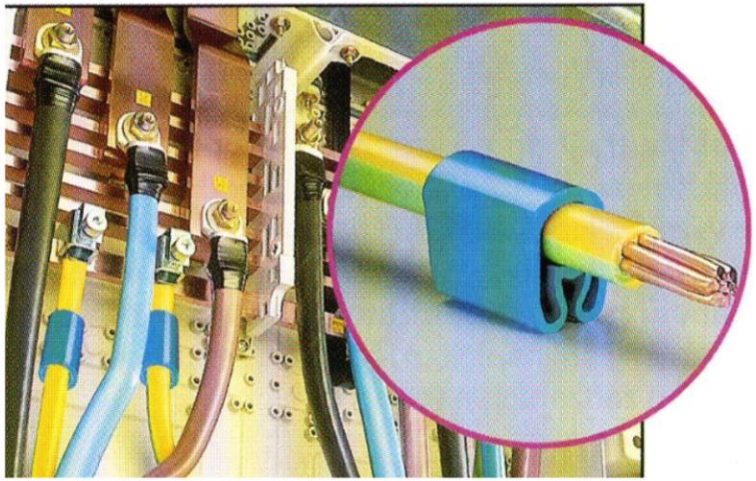
  - Bare conductors

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

- **DC supply system**

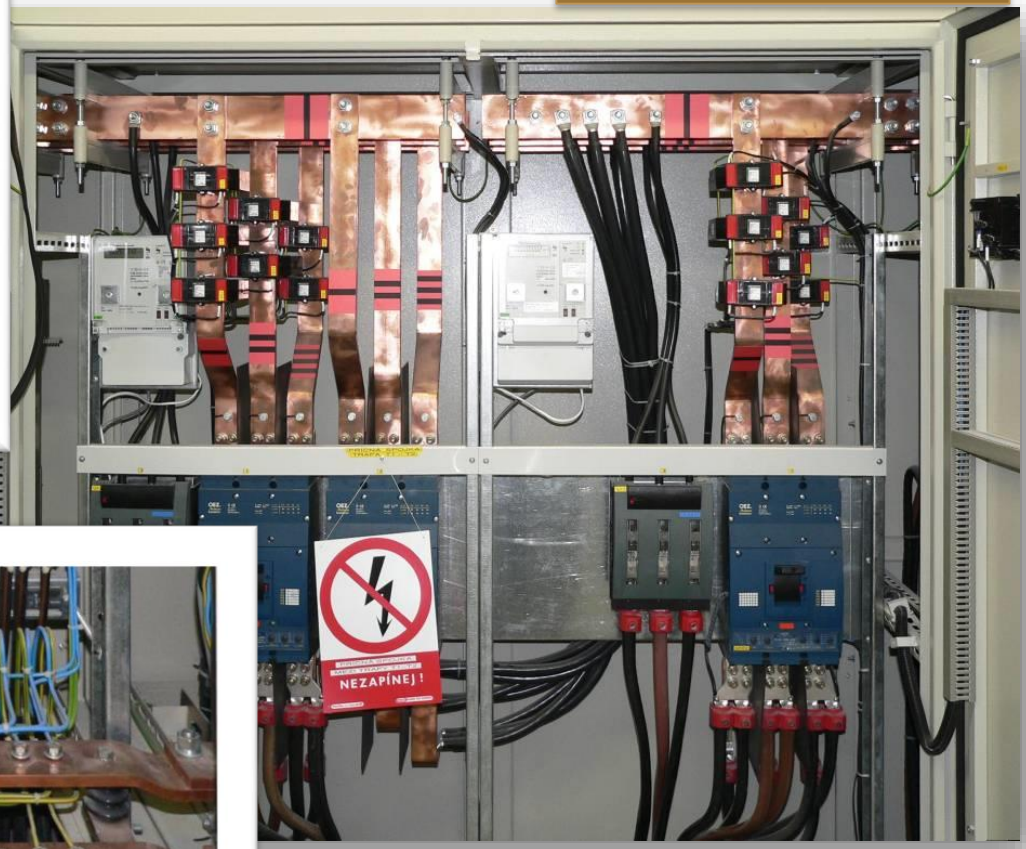
Conductor		Identification colour
L+	Positive	dark red
L-	Negative	dark blue
M	Mid-wire	light blue
PE, PEM	Protective earthing	green/yellow

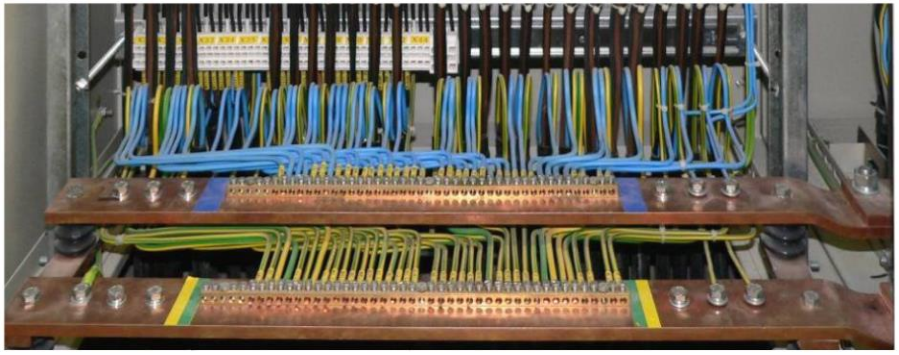
Colour identification of conductors - example



PEN conductor

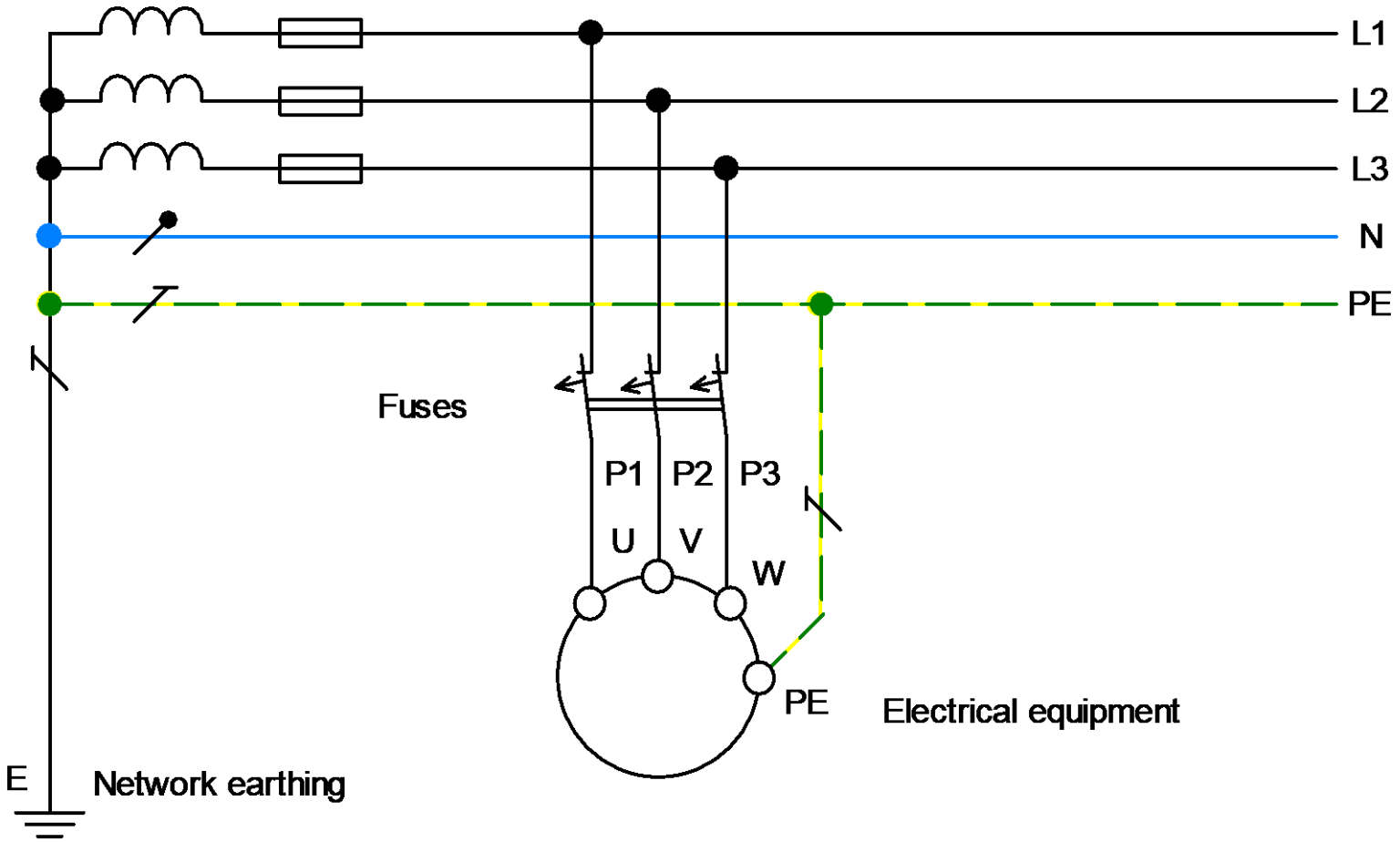
Bare buses





PE and N bridge

Example of colour and symbol identification

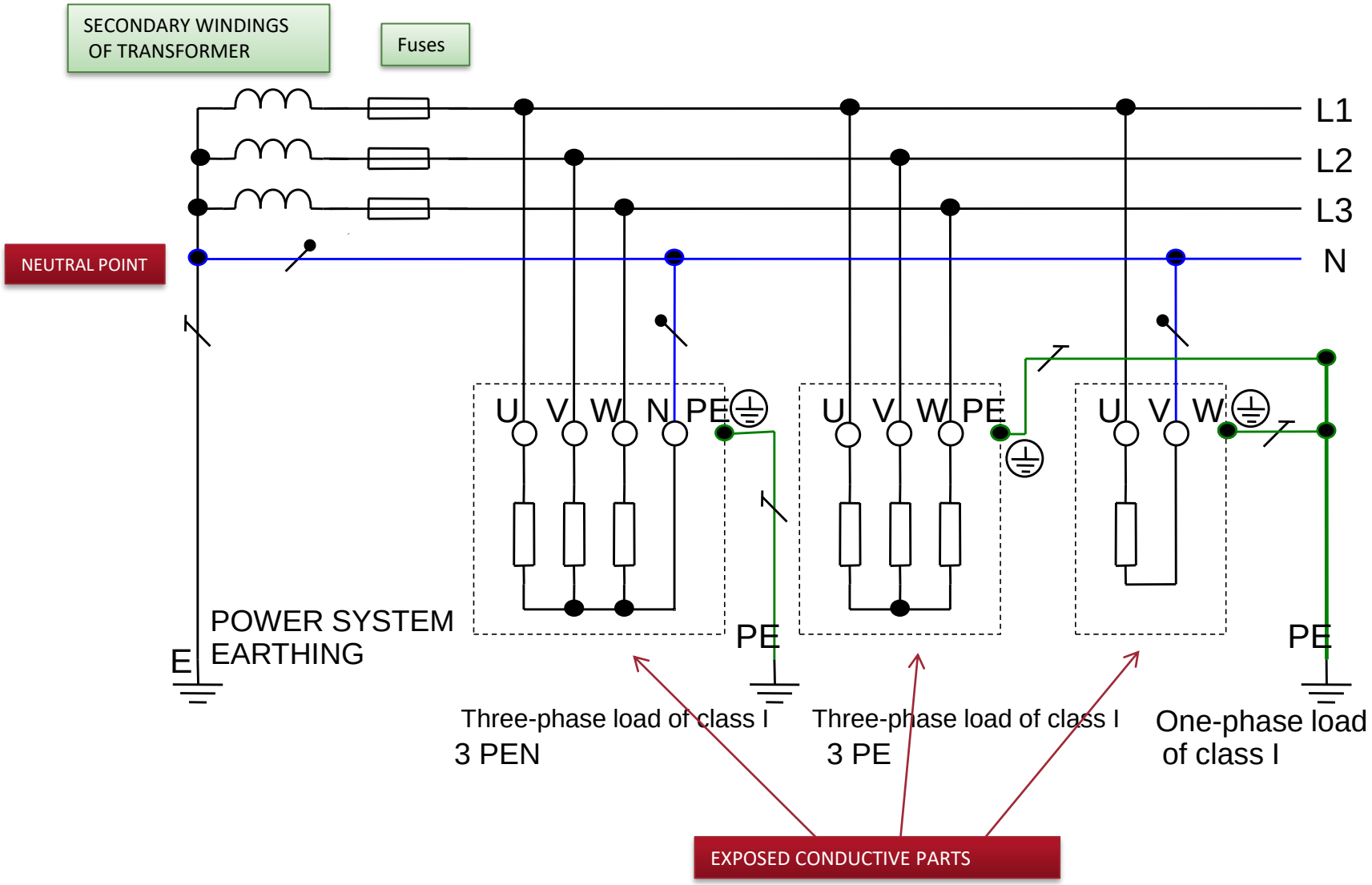


SAFETY SIGNS

Example

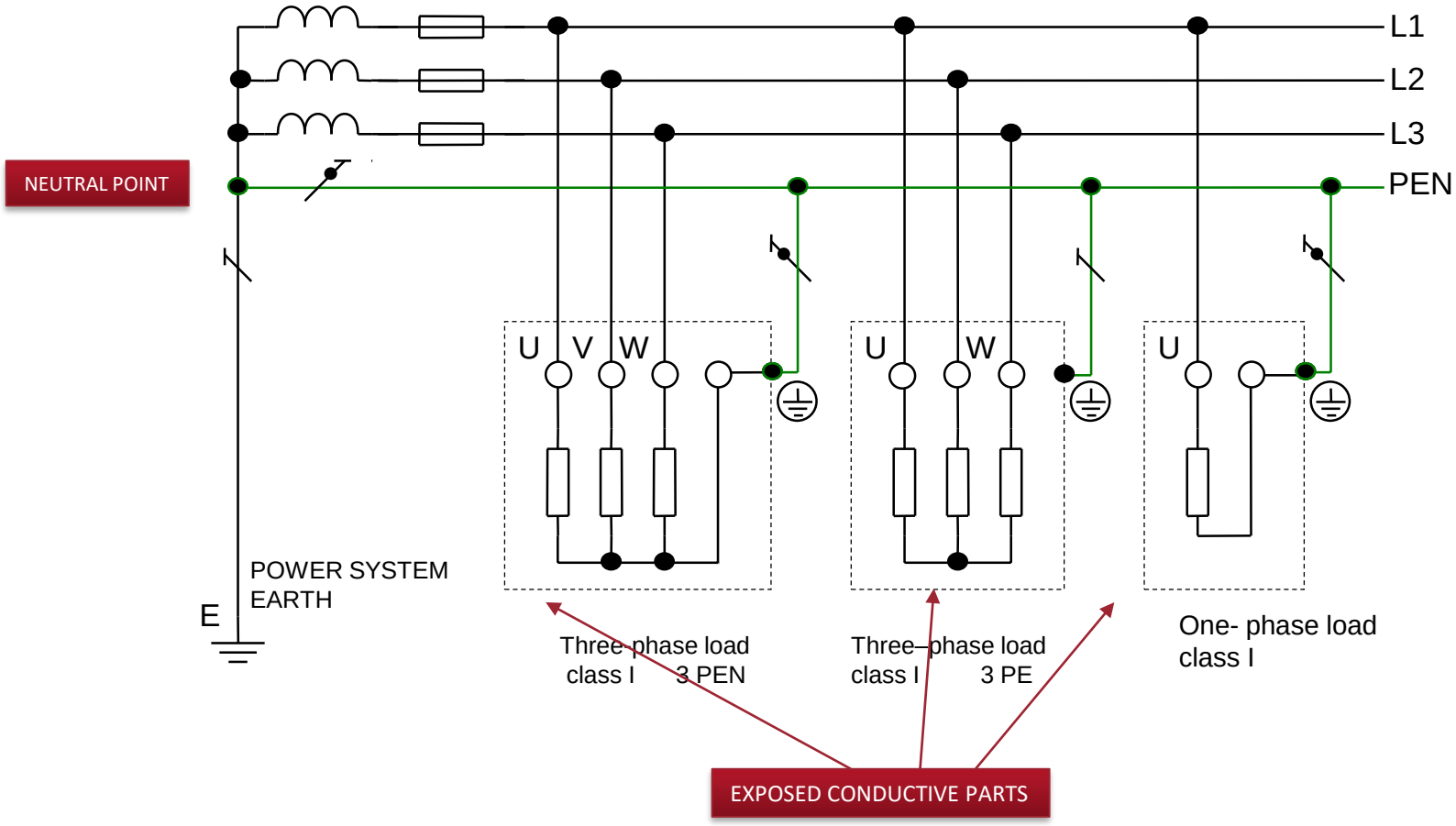
TT SYSTEM

DIRECT ELECTRICAL CONNECTION OF THE EXPOSED PARTS TO EARTH



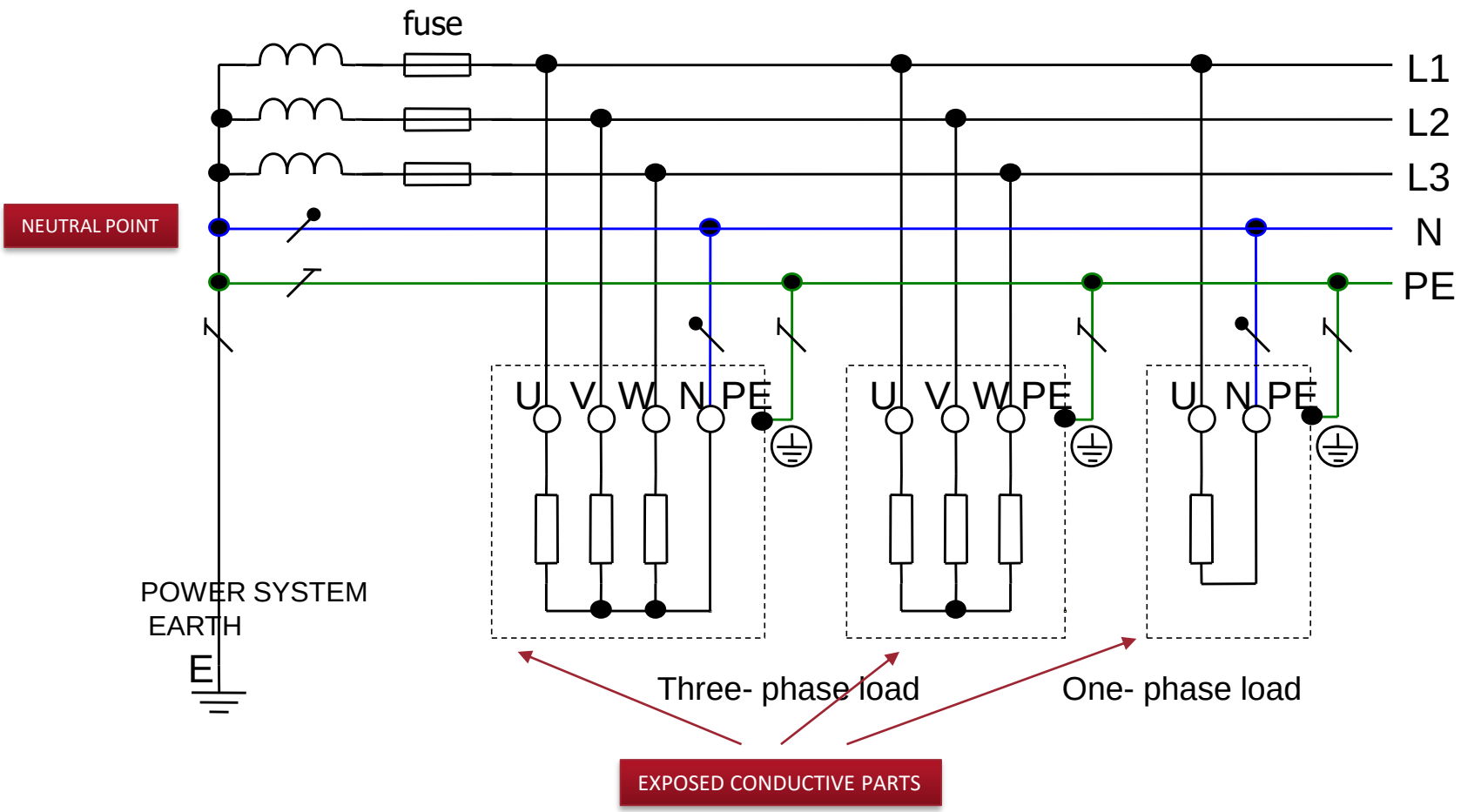
TN-C SYSTEM

NEUTRAL AND PROTECTIVE FUNCTIONS ARE COMBINED IN ONE WIRE

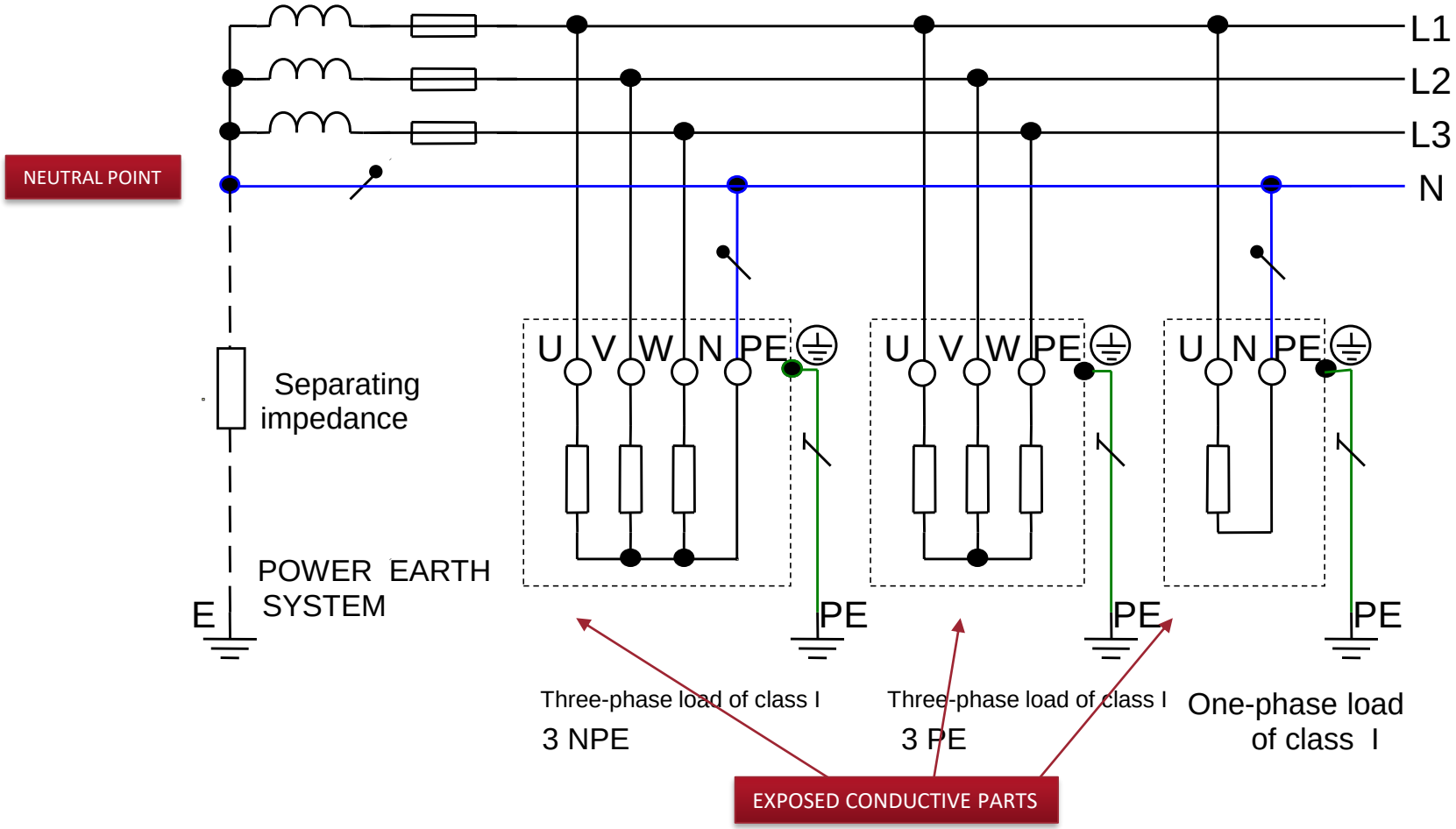


TN-S SYSTEM

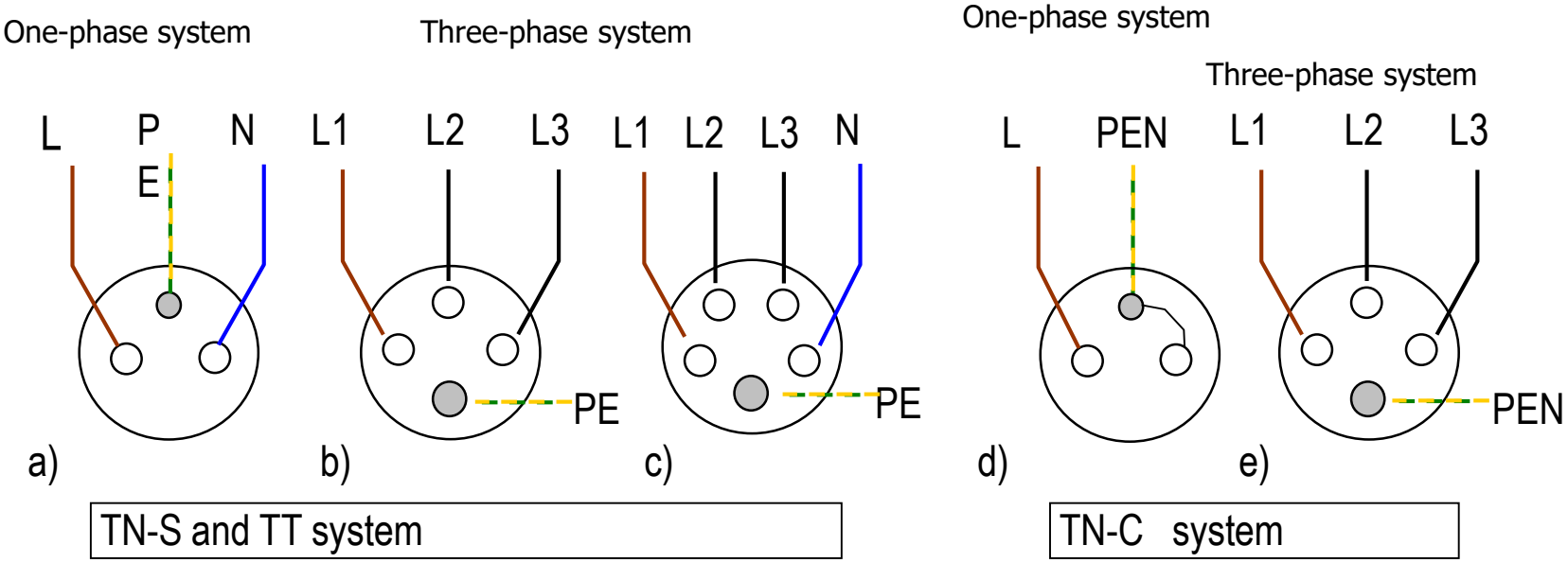
SEPARATE NEUTRAL AND PROTECTIVE CONDUCTORS



IT SYSTEM
LIVE PARTS ISOLATED FROM EARTH



Sockets of low voltage installation



Not allowed in new installations

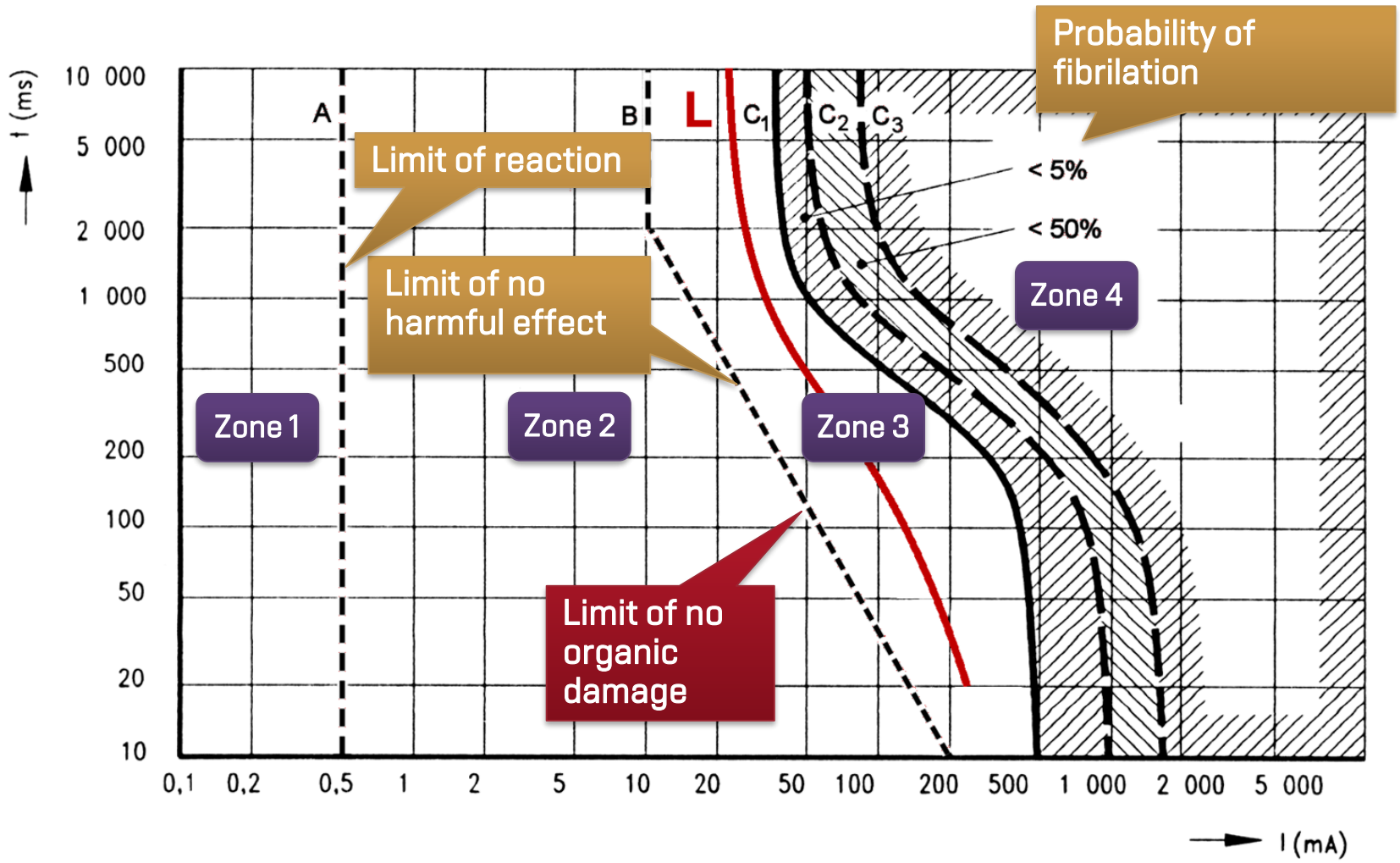
SAFETY IN LABORATORY

1. Student in school laboratories may work only under the supervision of a nominated 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 OF ELECTRIC CURRENT

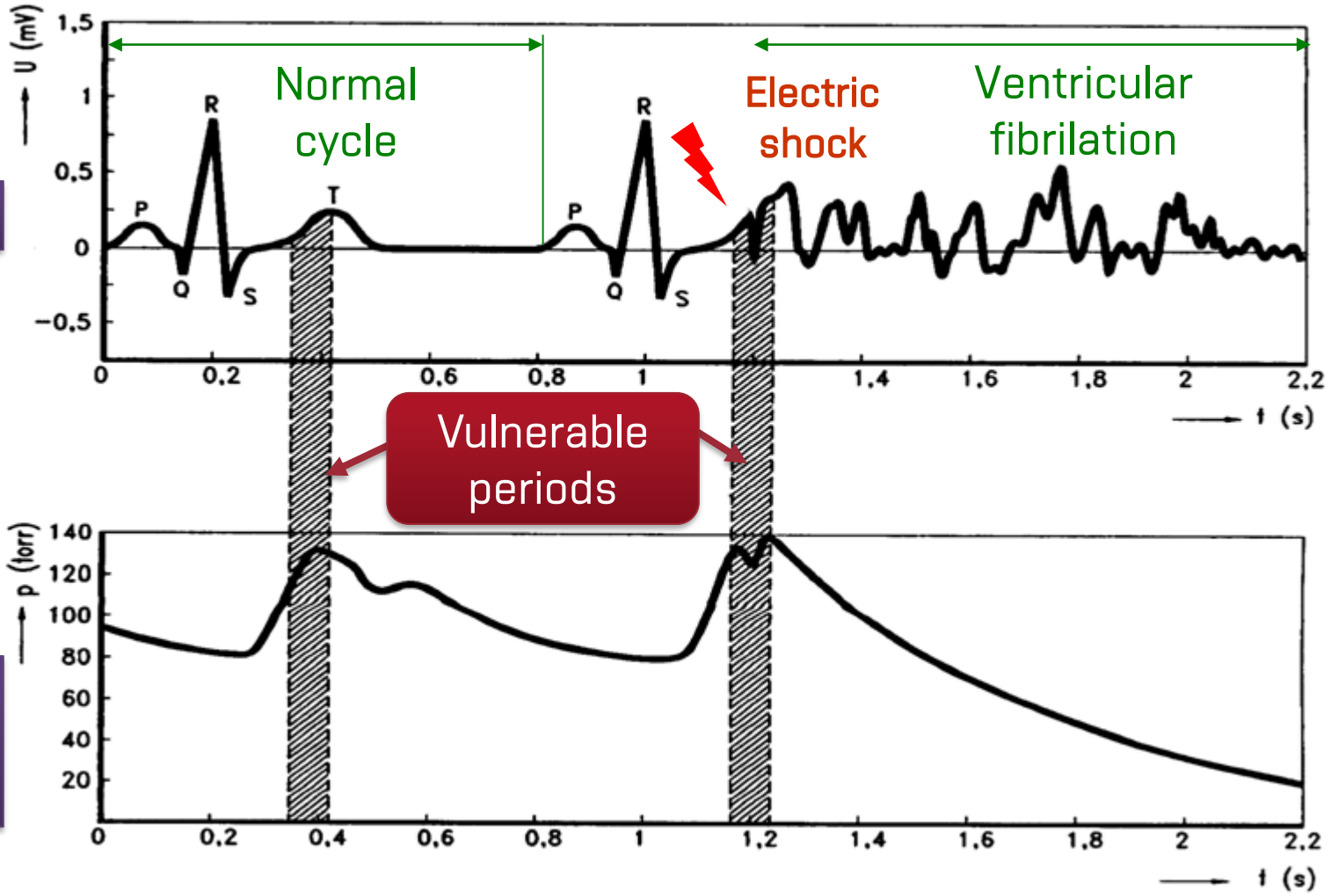
- The hazard primarily **depends on the value of current** passing through human body or on other effects caused electric or electromagnetic field
- Important parameters regarding the risk of electric shock:
  - Value and way of current through body
  - Time duration of current
  - Kind of current (DC,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

Time/current zones of effect of a.c. currents on persons (IEC 479-1)



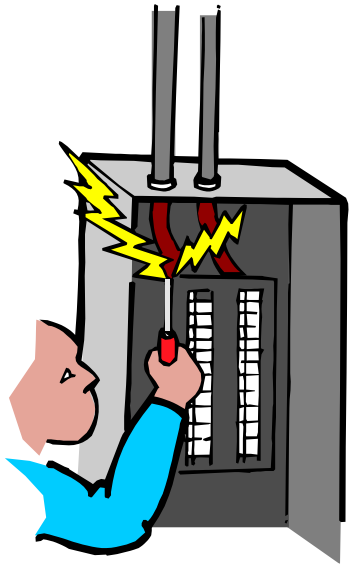
This diagram is valid for AC 15-100 Hz , way of current left hand to both legs

Cardiac cycle

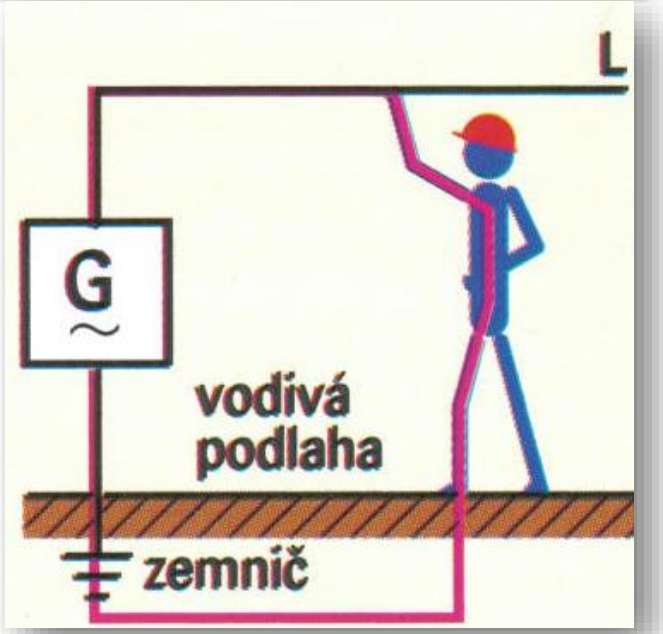


Different parts of EE

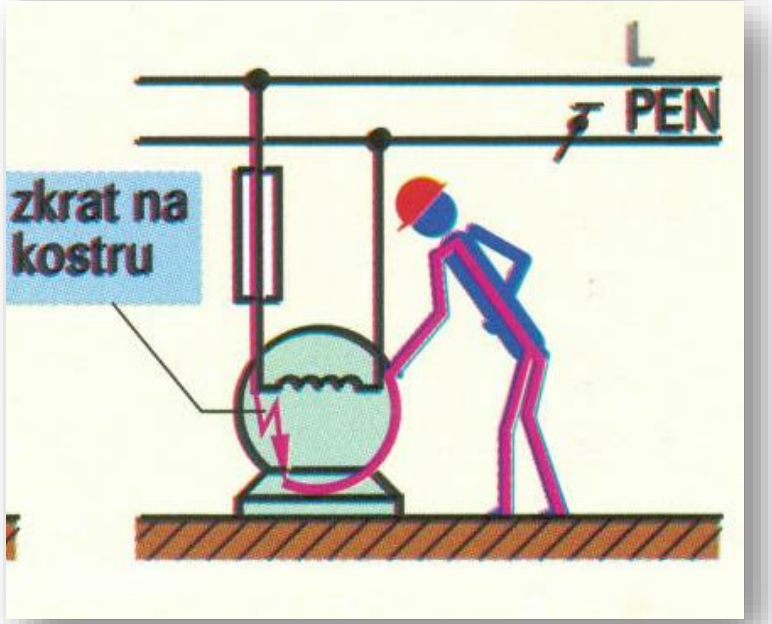
- **Live parts**
  designed to conduct electrical current (or have conductive connection to them)
- **Exposed-conductive parts**
  not designed to conduct current, can be touched, are not normally non-live, but can become live when basic insulation fails.
- Non-live parts, dead parts



Direct contact with dangerous live part

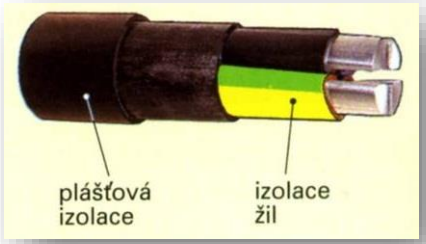


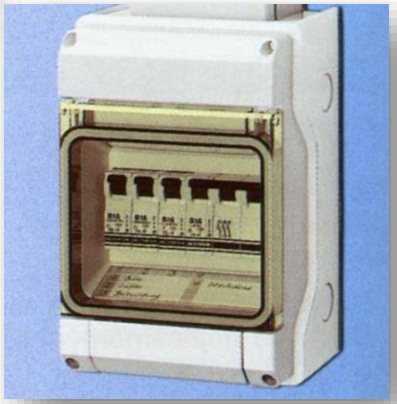
Indirect contact with exposed conductive part



Protection against direct contact

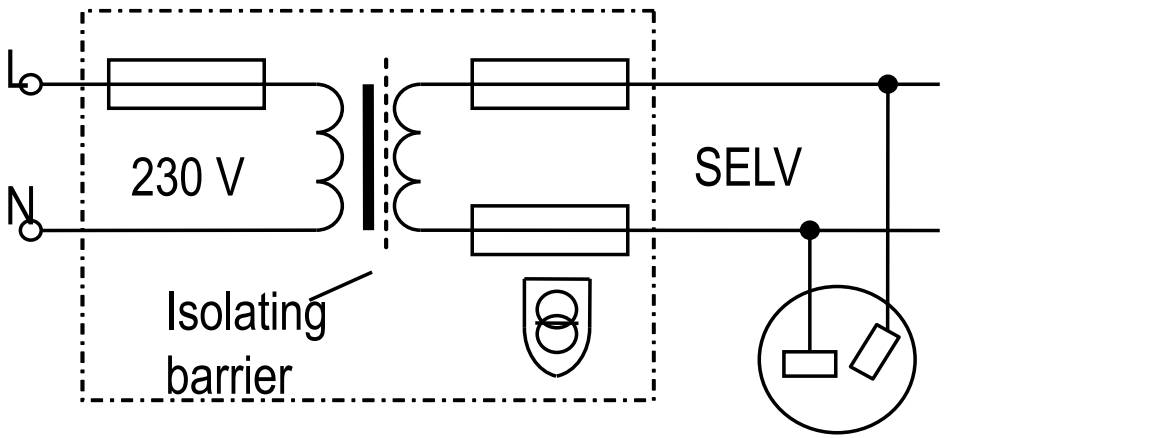
- Basic insulation
- Enclosures
- Obstacles
- By placing out of reach





SELV (Safety Extra Low Voltage)

- Max. 50 V~, 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 (ČSN EN 60529)

IP XX

Level	Effective against	Description
0	—	No protection against contact and ingress of objects
1	>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	>12.5 mm	Fingers or similar objects
3	>2.5 mm	Tools, thick wires, etc.
4	>1 mm	Most wires, slender screws, large ants etc.
5	Dust protec ted	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.

Examples of EE with different IP Code

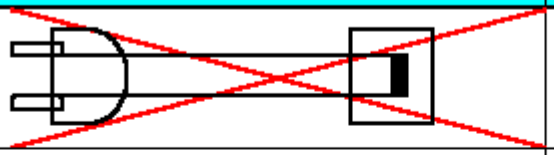
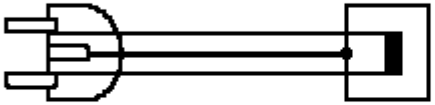
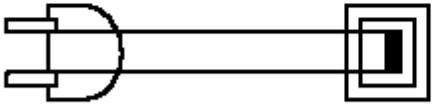
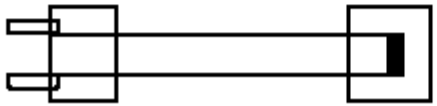
Socket IP 2X

Socket IP 44

Socket IP 55

Socket IP 66

Classification of electrical equipment (ČSN 33 0600)

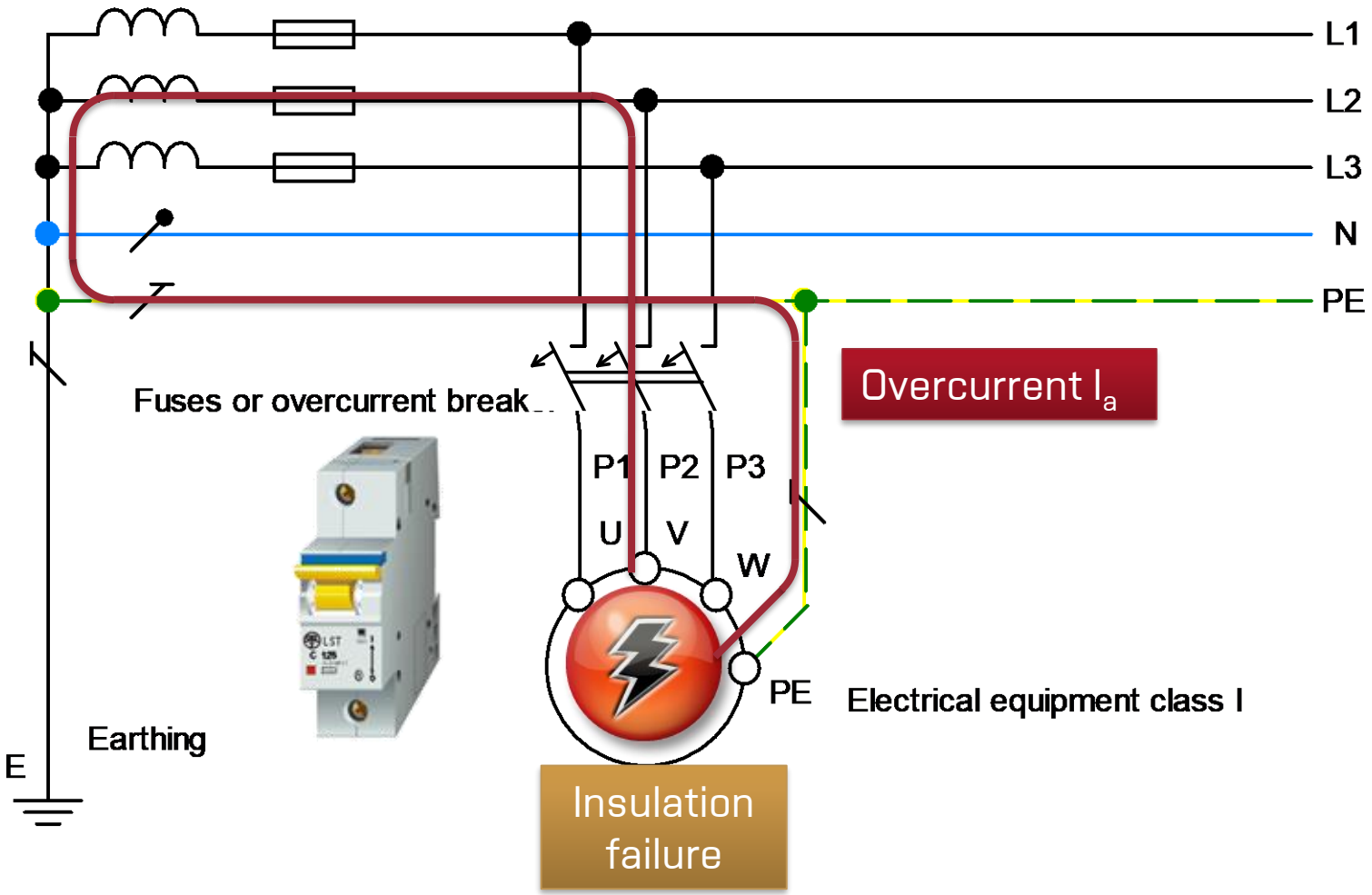
Class	Symbol	Principle of protection	Comment
0			Without protective system Not allowed in CZ
I	1)		Connection of exposed part with protective conductor of supply
II	2)		Doubled or reinforced insulation of electrical equipment
III	2)		Socket mustnot be unchangable Supply EXTRA LOW VOLTAGE

EE CLASS I

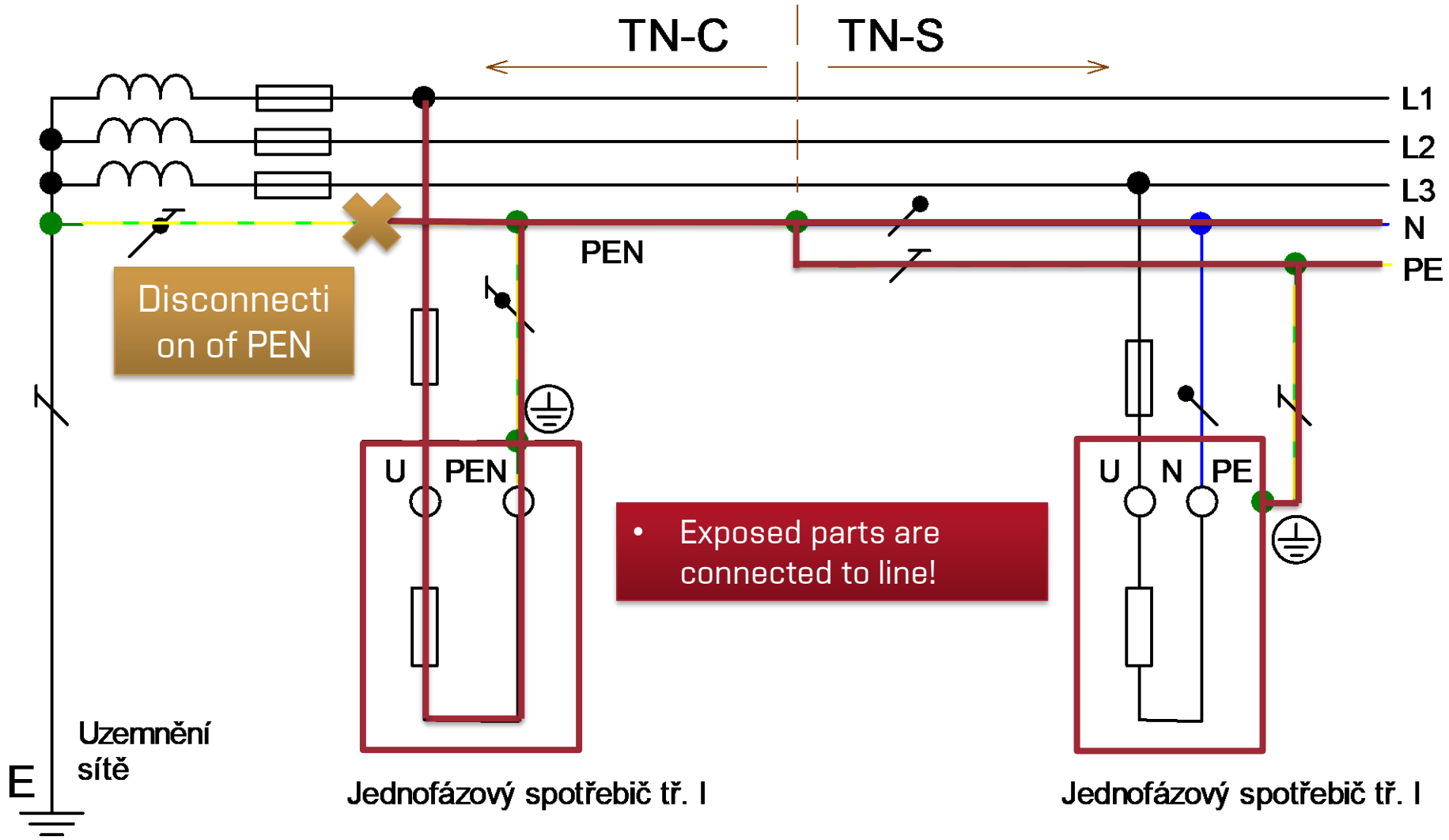
EE CLASS II


12V
RACING
www.tbys.com
www.tbys.com

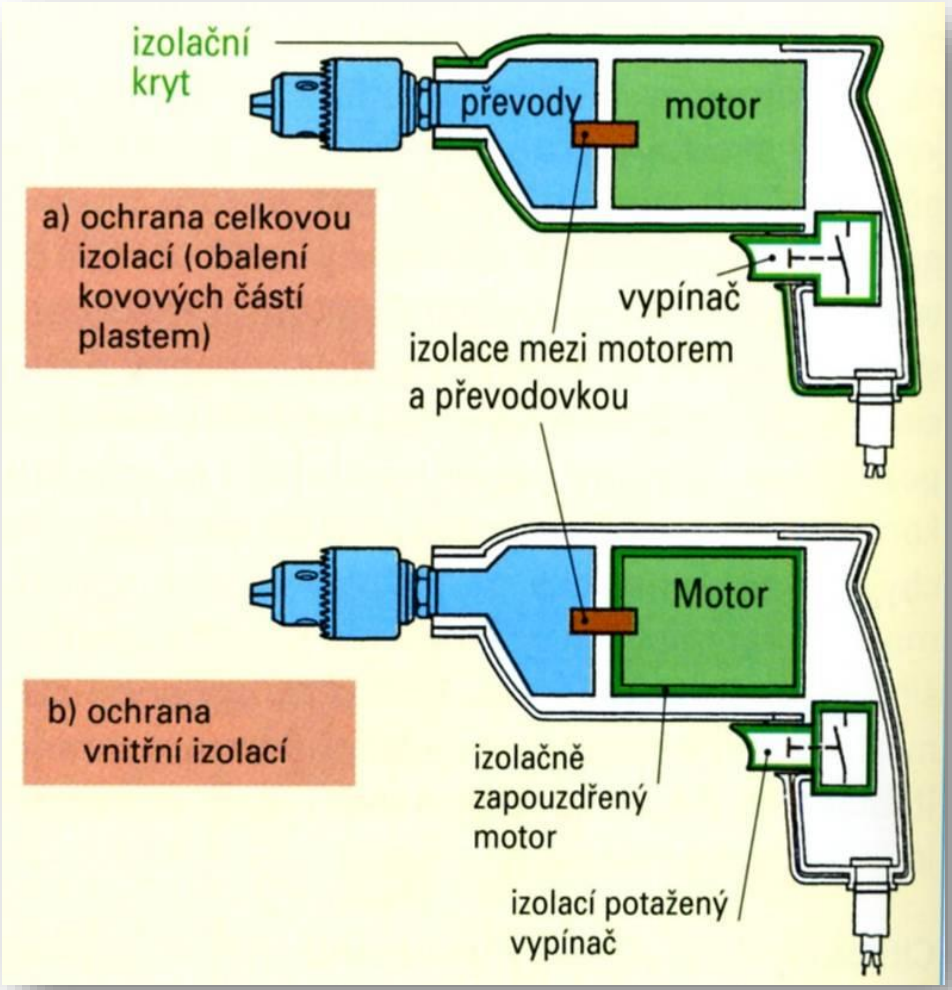
PROTECTION BY AUTOMATIC DISCONNECTION IN TN-S SYSTEM

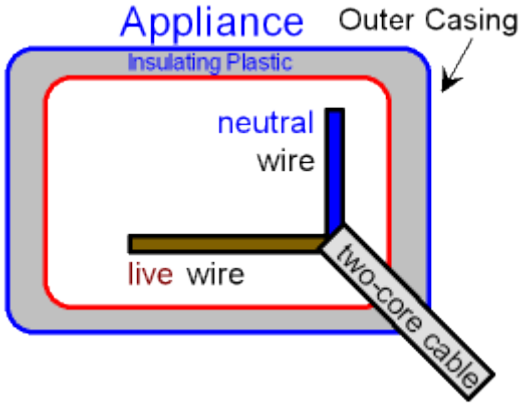


Failure of PEN conductor



DOUBLED INSULATION (EE CLASS II)





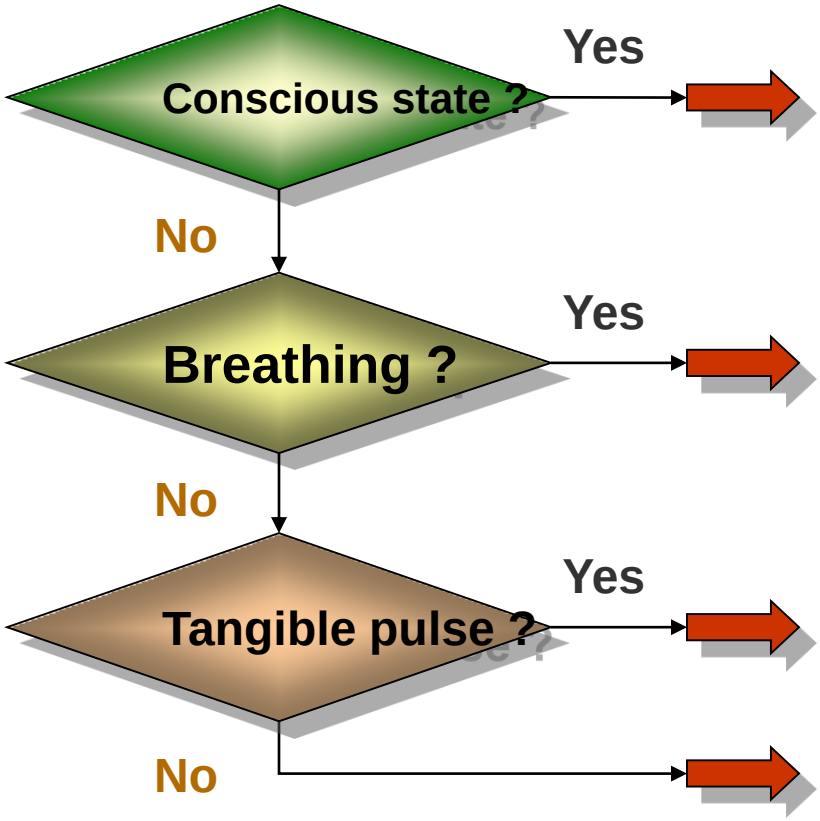
First aid

Results of electric shock

- 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)

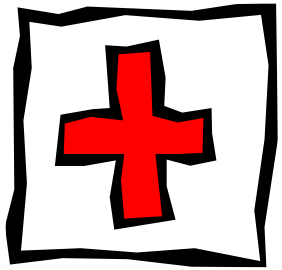
FIND OUT STAGE OF INJURY AND START FIRST AID TREATMENT



- Further injury ?
  - bleeding
  - Injury of spin?
  - Fractured bones
  - Burns

THE PROCEEDING OF THE RESCUE OF AFFLICTED PERSON

- Find out cause of injury and set afflicted person from the range of current
- Find out stage of injury and start first aid treatment
- Call for a medical first aid
- Inform adequate supervisor about the accident



CALL FOR FIRST AID

- National telephone numbers
  - **150** Fire rescue brigade of CZ
  - **155** Medical first aid service of CZ
  - **158** Police of Czech republic

- Europe first aid telephone number

  112

  - Integrated first aid system
  - In EU are national first aid telephone numbers also respected

AED – Automated external defibrilator

Intended for use by non-skilled person:

… and that’s all