

BASIC HEALTH AND OCCUPATIONAL SAFETY REGULATIONS

SAFETY IN ELECTRICAL ENGINEERING

Czech Technical University in Prague

Faculty of Electrical Engineering

Recommended literature

This lecture:

http://bezpecnost.feld.cvut.cz/bezb/prednaska_en.pdf

Textbook:

Kříž, M., Kůla, V.:

Introduction to Electrical Engineering

http://bezpecnost.feld.cvut.cz/bezpecnost_en.pdf

System of safety courses during the study

EN 50110-1 Operation of electrical installation

Government Regulation No.194/2022

Directive of the Dean

SAFETY COURSE	Symbol	Date	Program	Study
Basic Health and Occupational Safety regulations	BEEZZ	At the beginning of the 1st semester	All programs	Bachelor
Safety in Electrical Engineering for a bachelor's degree	BEEZB	1st semester	EEM, EK, OES, KYR, EEK, EECS	
		2nd semester	OI SIT	
Safety in Electrical Engineering for a master's degree Repeated BEEZZ	BEEZM	1st semester	All programs	Master



Basic Occupational Safety and Health training record

Training day:

Faculty of Electrical Engineering

Supervisor: Ing. Vladimír Kůla, CSc

Signature: _____

Occupational Safety and Health training curriculum:

1. System of safety courses during the study
2. Legal Basis for Health and Occupational Safety
3. Duties of the Employer
4. Duties of the Employee
5. Decree of the Czech Occupational Safety Office no. 48/82 Law Code
6. Safety of work with electrical equipment.
7. Accident at work, recording and registration
8. Working condition of women and juveniles
9. Security of work with computers
10. First Aid – traumatological plan
11. Laboratory rules, fire prevention
12. Emergency calls

Date of birth

I confirm that I was instructed and that I understand to it.

	<u>Surname and name</u>	Date of birth:	Study group	Signature
1				
2				
3				
4				
5				

signature

Purpose of this course

To give the basic knowledge of electricity –
as much as to be able to recognize the danger
of electricity and to avoid it.



Basic health and occupational safety regulations

SAFETY COURSE	Symbol	Date	Program	Study
Basic Health and Occupational Safety regulations	BEEZZ	At the beginning of the 1st semester	All programs	Bachelor

Hours of lectures:

1x2 hours in the 1st week of semester

Hours of seminars:

1x2 hours in the 2nd week or in the 3rd week of semester

Record to student's record:

in the 2nd or 3rd week of semester

Record to KOS:

in the 4th week of semester

Check of completion (KOS):

in the 5th week of semester

Number of credit units:

0



Safety declaration

CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF ELECTRICAL ENGINEERING

Occupational Health and Safety Requirements for ERASMUS Students

The CTU in Prague and the staff and students of the Faculty of Electrical Engineering have a legal requirement to promote safe working conditions for staff and students, and to manage risks where they exist.

- Students must conduct themselves in an appropriate and responsible manner to ensure their own safety and the safety of others.
- Students must comply with instructions of any staff and any safety notices.
- Students must remain within designated areas.
- They must comply with the safe operating procedures for the prescribed work
- Students must not touch any equipment unless instructed to do so by a responsible teacher or tutor.
- It is forbidden to operate any machinery or equipment if it is known to be in an unsafe condition.
- Students immediately report any recognized potentially unsafe condition or act to your supervisor.
- Student immediately report accidents, injuries, and property damage to a supervisor.
- Smoking is not permitted in the buildings.
- Unauthorised consumption of alcohol or taking illegal or excessive legal drugs during work hours, or commencing work under the influence of alcohol or drugs, is not permitted.
- Every student observes the warning and safety signs that are displayed throughout the faculty.

Students may only enter a laboratory, only if they have received special authorization after passing **safety course** from a responsible department.

However, access to the laboratories is restricted for safety reasons, and students may not enter a laboratory unless they are under the direct supervision of a responsible teacher or tutor.

Information about **safety courses** are published on the website:

<http://bezpecnost.feld.cvut.cz/bpzs/>

Any student who disregards the University's safety procedures and endangers either their own safety or the safety of fellow students may be subjected to the University's disciplinary procedure, which could ultimately result in dismissal from the faculty.

Safety declaration:

I acknowledge that I have read, understood, and will comply with the Occupational Health and Safety requirements during sessions at Faculty of Electrical Engineering.

Name: _____ Surname: _____

Nationality: _____ Passport Number: _____

Date: _____ Signature: _____

Study Office: _____

Electrical qualification of persons

Electrical qualification of persons	
Ordinary person	A person who is neither a skilled person nor an instructed person – person without any qualification
Instructed person	A person adequately advised or supervised by skilled person to enable him or her to avoid dangers which electricity may create
Skilled person	A person with relevant education and experience to enable him or her to avoid dangers which electricity may create

EN 50110-1 Operation of electrical installation

Safety work on electrical equipment

Threatening danger:

- accident by electric current
- fire
- explosion

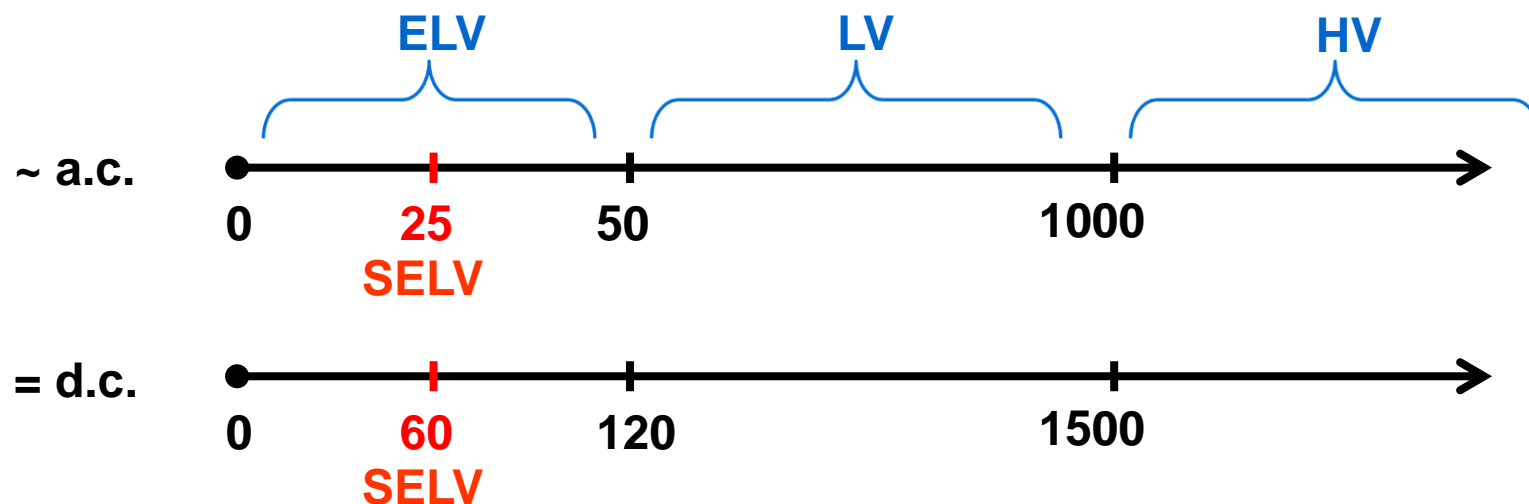
Every employee must get at least the lowest qualifications according to Government Regulation No.194/2022

Acquainted persons These are the employees (ordinary persons) acquainted with regulations on treatments with electric equipment and aware of the possible danger of electric current.



Category of voltages

CATEGORY OF VOLTAGE		a.c.	d.c.
Extra low voltage	ELV	< 50 V	< 120 V
Low voltage	LV	50 V to 1000 V	120 V to 1500 V
High voltage	HV	>1000 V	>1500 V



(SELV = safety extra low voltage)

Allowed activities (operation)

1. They can independently manipulate only electrical equipment of a safety extra low voltage SELV; and low voltage but only if they cannot touch the live parts (parts under voltage) during a normal operation.
2. Switching on and off, plugging into the socket, moving connecting cables, exchange of bulbs when switched off and exchange of safety fuses.
3. They can perform maintenance work without the dismantling with instruments (dry cleaning) when the equipment is switched off.
4. There must be a safe distance from unprotected working parts under voltage up to 1 kV at least **1 meter**.

Forbidden activities

1. To repair electrical appliances and distribution network.
2. To work on parts of electrical equipment under voltage.
3. To use electrical equipment suspected of damage.
4. To move electrical appliances connected to the network (computers, electrical typewriters, calculators etc.) unless they are intended for such usage – (electrical hand tools) – unplugging of the socket.
5. To touch electrical equipment by wet parts of the body.
6. To clean the surface of electrical equipment by wet means.

Basic terms and definitions for electrical safety

Live part	conducting part which is intended to be energized in normal use, including a neutral conductor
Exposed conductive part	conductive part of electric equipment, which can be touched and which is not normally live but which can become live when basic insulation fails
Basic insulation	insulation of hazardous live parts providing the first protection against electric shock

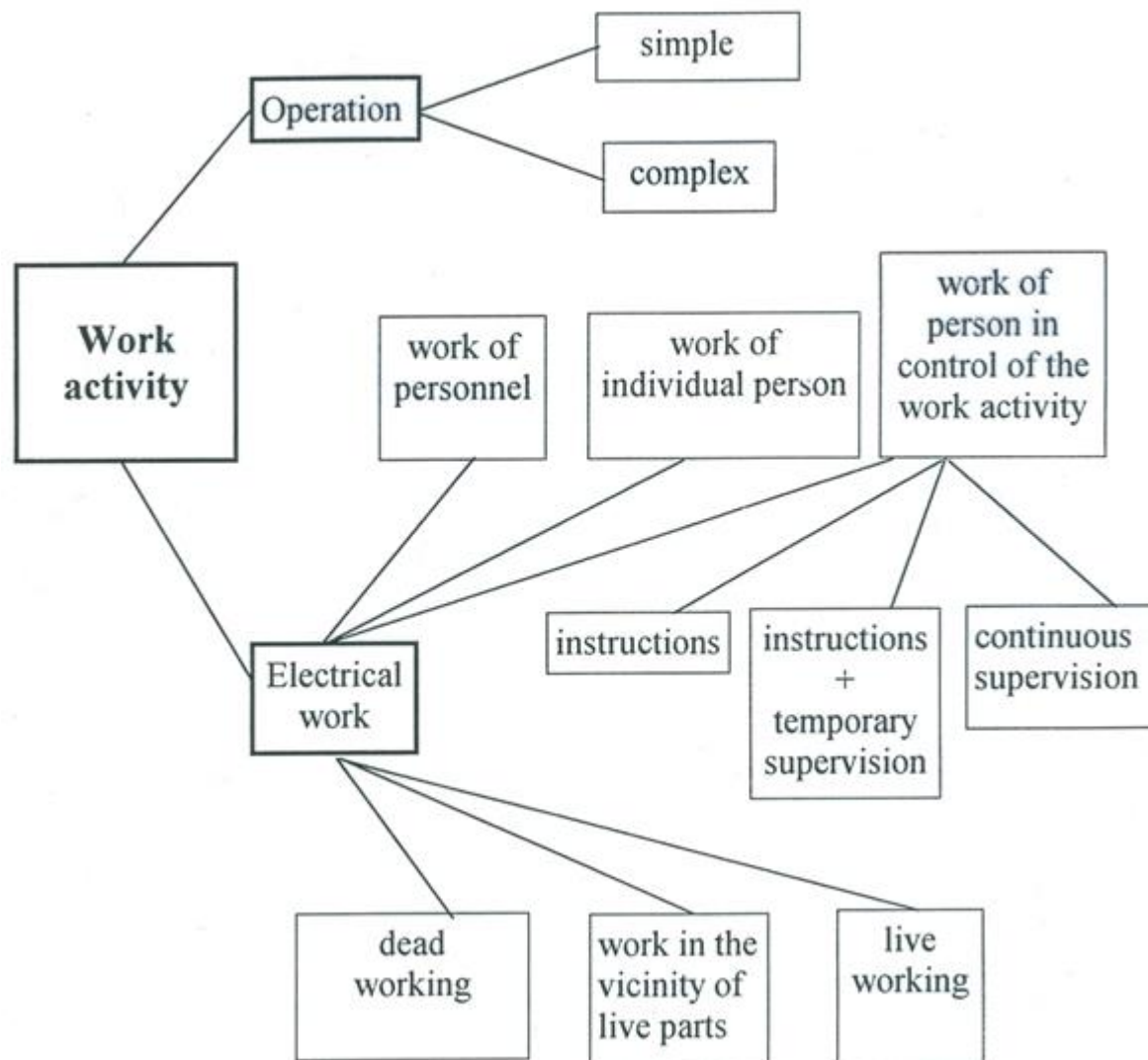
Direct contact	contact with live parts
Indirect contact	contact with exposed conductive parts, which have been become live under fault conditions



Work and operation

Operation	all activities necessary to permit the electrical installation to function both under normal and abnormal conditions
Work activity	any form of work where there is the possibility of an electrical hazard
Electrical work	work on, with or near electrical installation

Work activity





Characteristic features of operation and work

Characteristic features of operation and work			
Manipulation mode		Operation	Work
1	Direct contact	no	yes
2	Application of tools	no	yes
3	Duration of changes	temporary	permanent



Safety work with computers – 1

Risks of common users regarding Health and Occupational Safety and occupational disease occurrence:

- a) increasing eye-strain (brightness, blinking)
- b) electromagnetic radiation
- c) strain to the neck-spine

ad a)

1. the worker at the screen shall have neither the light source nor its reflection (a window, lamp etc.) in the range of view
2. the brightness of the objects in the neighbourhood of the screen shall be balanced so as not to produce big contrasts
3. the artificial enlightening of the room shall not form dark nooks and overlighted places – the upper margin of the active area of the screen shall be on the eye level at maximum.
4. the distance of the screen shall be at least 40 cm



Safety work with computers – 2

ad b)

if possible, place a monitor in such a way as to prevent the people from having access from its sides

ad c)

1. the placement of the keyboard: if sitting straight, the arms, placed with their palms on the keyboard, shall be perpendicular at the elbows
2. the height of the seat: if the soles are fully tread-down on the floor, the legs shall be perpendicular at the knees

Safety signs and safety colours

Sign	Safety colour		Symbol or text
	Background colour	Foreground colour	
Prohibition	white	red circular band and crossbar	black 1)
Mandatory action	blue		white 2)
Warning	yellow	black triangular band	black 2)
Information	green		white



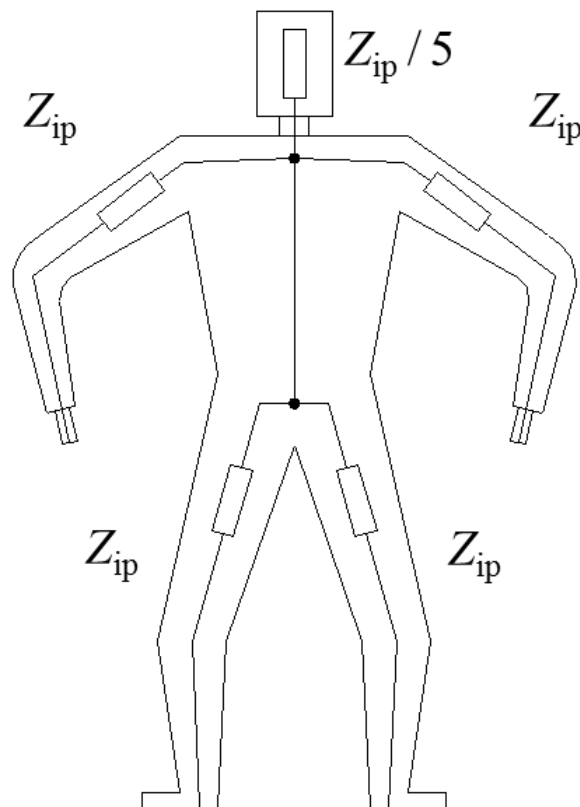
Geometric form	Meaning
	Prohibition or mandatory action
	Warning
	Information (including instructions)



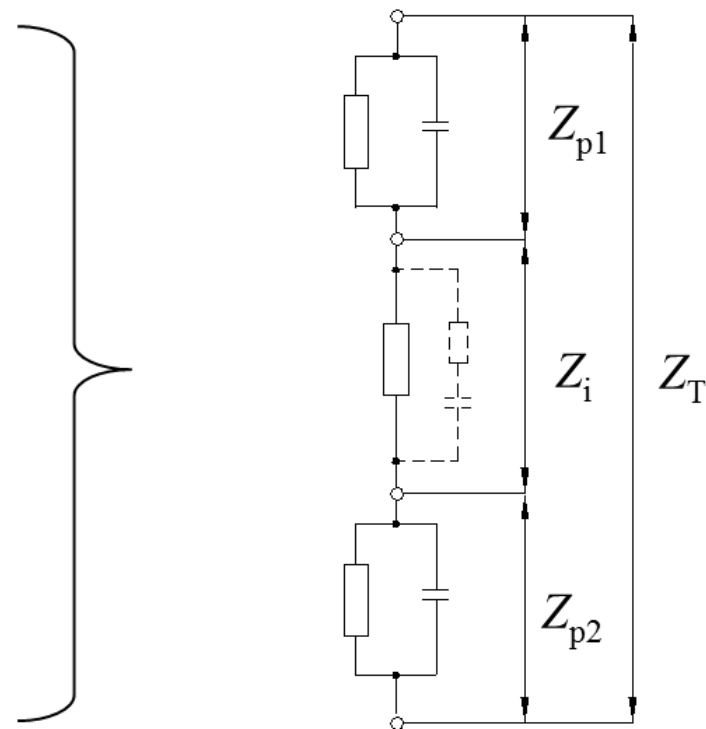
General meaning of safety colours

Safety colour	Meaning of objective	Example of use
Red	Stop Prohibition	Stop signs Emergency stop Prohibition signs
	This colour is also used for fire-prevention and fire-fighting equipment and its location	
Blue	Mandatory action	Obligation to wear personal protective equipment
Yellow	Caution, risk of danger	Indications of dangers (fire, explosion, radiation, toxic hazards, etc.) Warning for steps, low passages, obstacles
Green	Safe condition	Escape routes Emergency exits Emergency showers First aid and rescue stations

Human body impedance – model



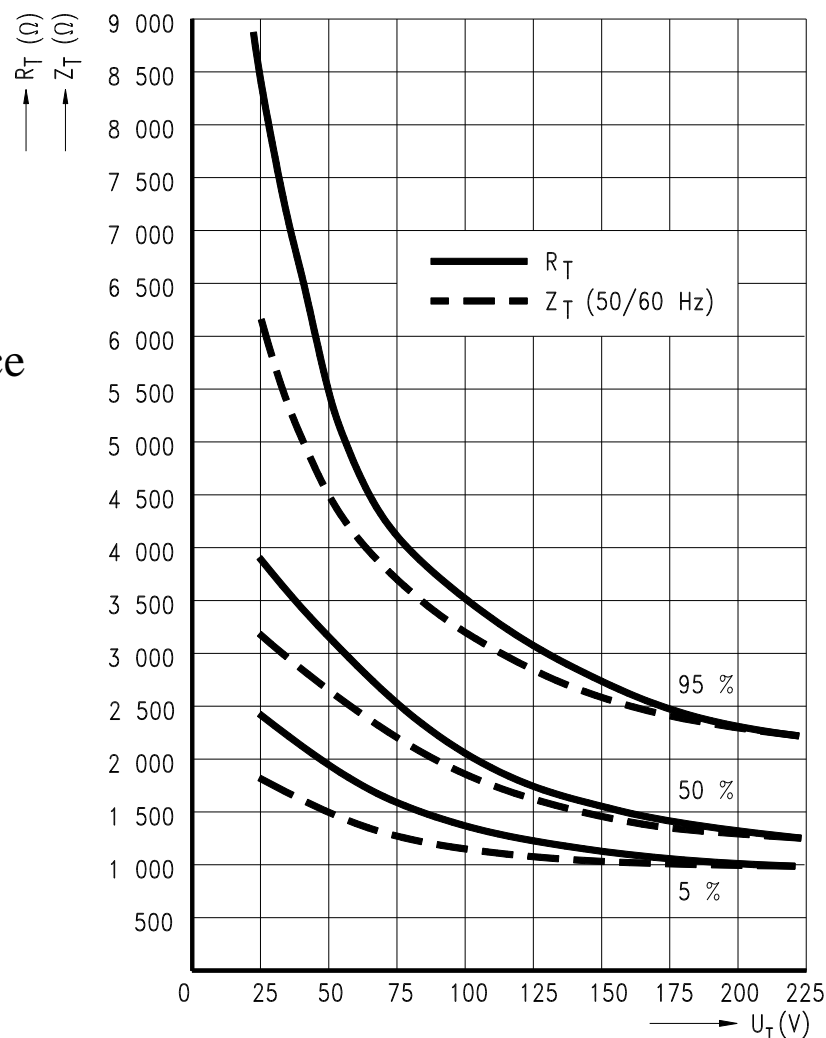
Human body as an electric object – simplified model (Z_{ip} is internal impedance of one hand or leg).



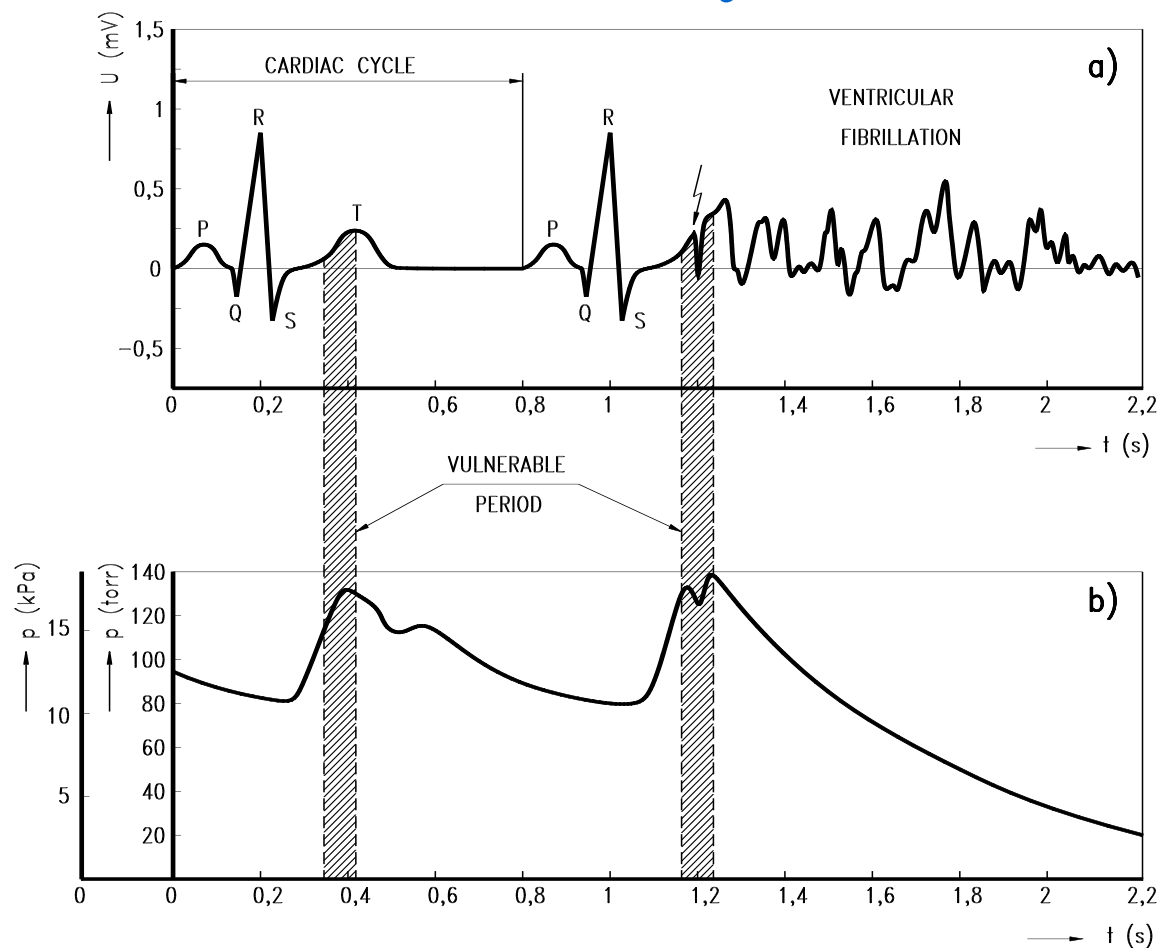
Z_i – internal impedance,
 Z_{p1}, Z_{p2} – impedance of the skin
 Z_T – total impedance of human body

Effects of current passing through the human body – 1

Total body impedance



Effects of current passing through the human body – 2



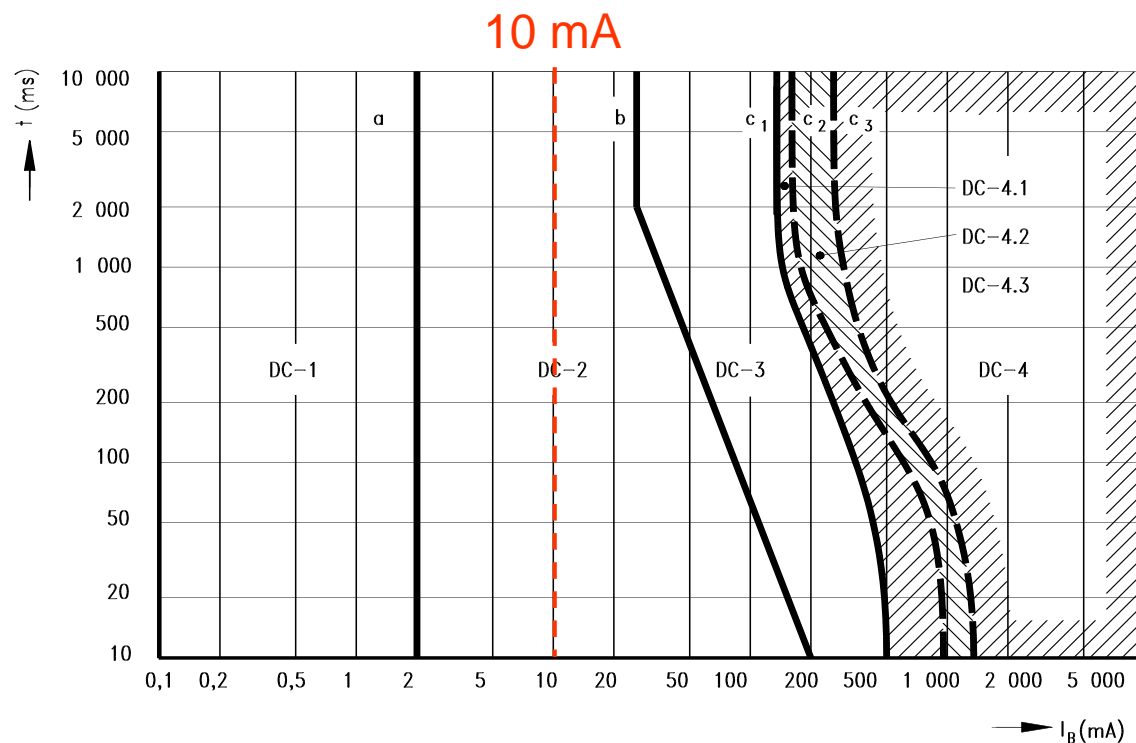
Ventricular fibrillation in the vulnerable period.
Effects on electrocardiogram and blood pressure.

3,5 mA



24

Effects of current passing through the human body – 4



Safety limits of steady electric current and electric charge

Safety limits of steady **electric current** passing through the human body and accumulated **electric charge**

Steady electric(touch) current and accumulated electric charge			
Physiological effects of current and charge	Values of safety limits		
	Electric current (mA)		Charge (μC)
	Alternating current	Direct current	
Threshold of perception	0,5	2	0,5
Threshold of pain	3,5	10	50
Let-go- current	5	25	

Limits of safety extra low voltage at live parts

Direct contact with live part

Conditions	Safety extra low voltage at live parts (V)	
	Alternating current	Direct current
Usual and wet conditions or conditions with corrosion aggressiveness	25	60
Very bad conditions (a man standing in water or in metal barrels etc.)	–	–

Possible only direct contact with protective enclosure

Conditions	Safety extra low voltage at live parts (V)	
	Alternating current	Direct current
Usual and wet conditions or conditions with corrosion aggressiveness	50	120
Very bad conditions (a man standing in water or in metal barrels etc.)	12	25

The highest permissible touch voltages (conventional touch voltage limits)

A. Permanently acting touch voltage

Conditions	The highest permissible touch voltages (V)	
	Alternating current	Direct current
Usual and wet conditions or conditions with corrosion aggressiveness	25	60
Very bad conditions (a man standing in water or in metal barrels etc.)	–	–

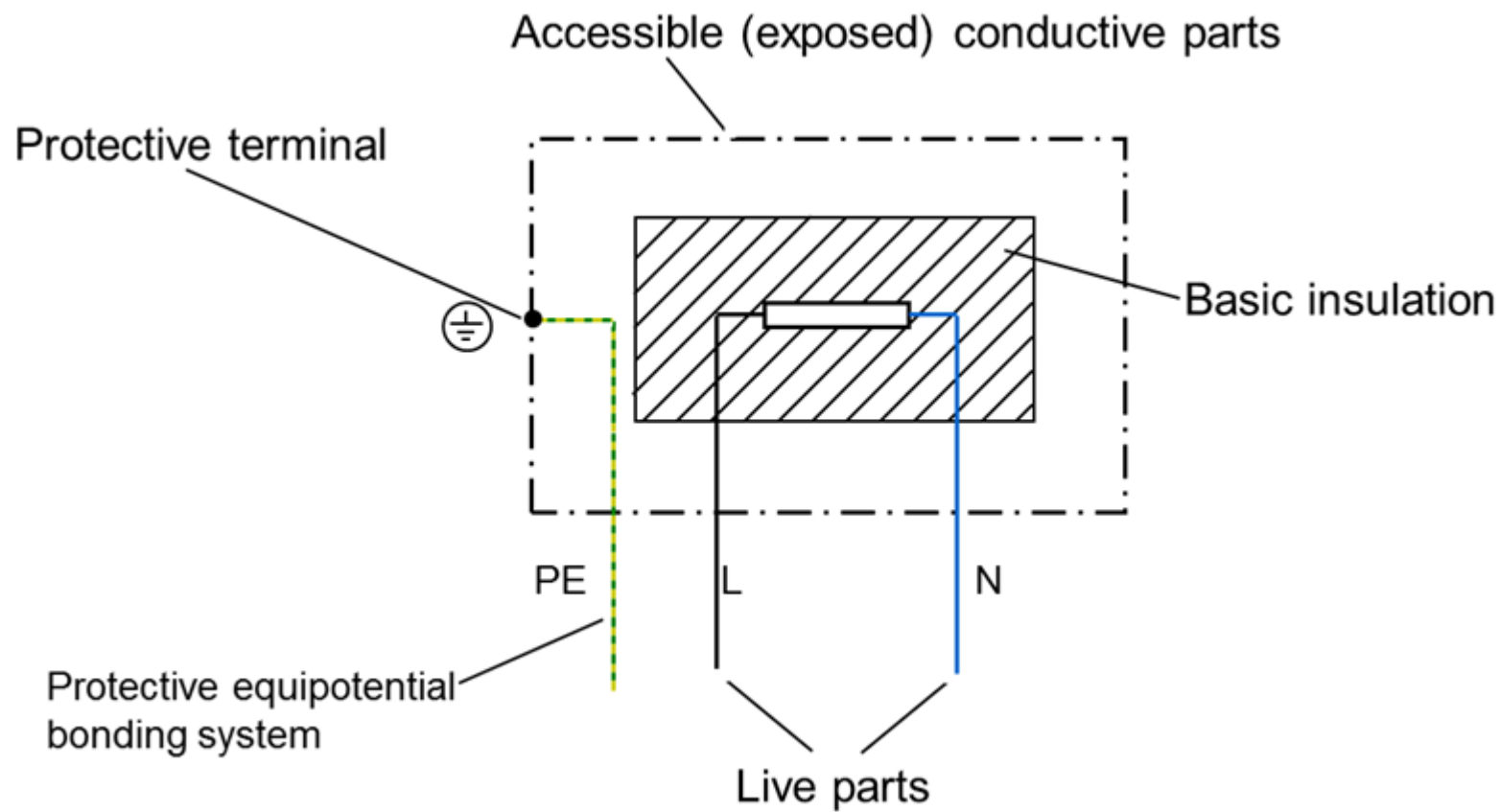
B. Short-term acting touch voltage (duration of fault condition)

Conditions	The highest permissible touch voltages (V)	
	Alternating current	Direct current
Usual and wet conditions or conditions with corrosion aggressiveness	50	120
Very bad conditions (a man standing in water or in metal barrels etc.)	12	25

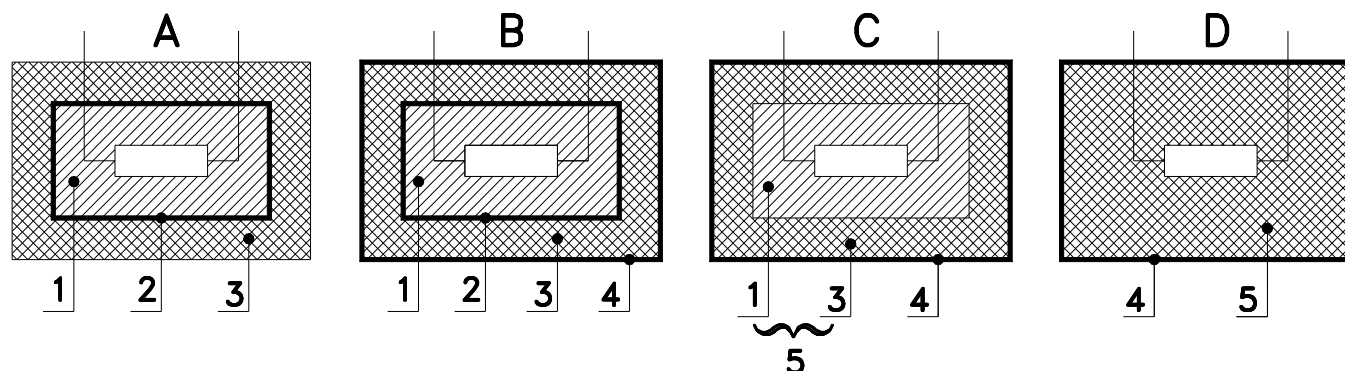
Characteristics of equipment according to the classification

Class of protection	Protective provisions		
	in the equipment		in the installation
	BASIC protection	FAULT protection	
0 ^{*)}	Basic insulation	–	Non-conducting environment
			Electric separation (with one supplied apparatus)
I	Basic insulation	Protective equipotential bonding	Automatic disconnection of supply
II	Basic insulation	Supplementary insulation	–
	Reinforced insulation		
III	Safety limits of touch voltage	–	SELV circuit
Legend: ^{*)} According to CSN the application of Class 0 equipment is in the Czech Republic prohibited. The description is made by reason of identification.			

Class I equipment



Class II equipment






Principle diagrams for Class II equipment

- 1 – basic insulation
- 2 – internal metal part
- 3 – supplementary insulation
- 4 – outside metal part
- 5 – reinforced insulation

Symbol of Class II equipment:

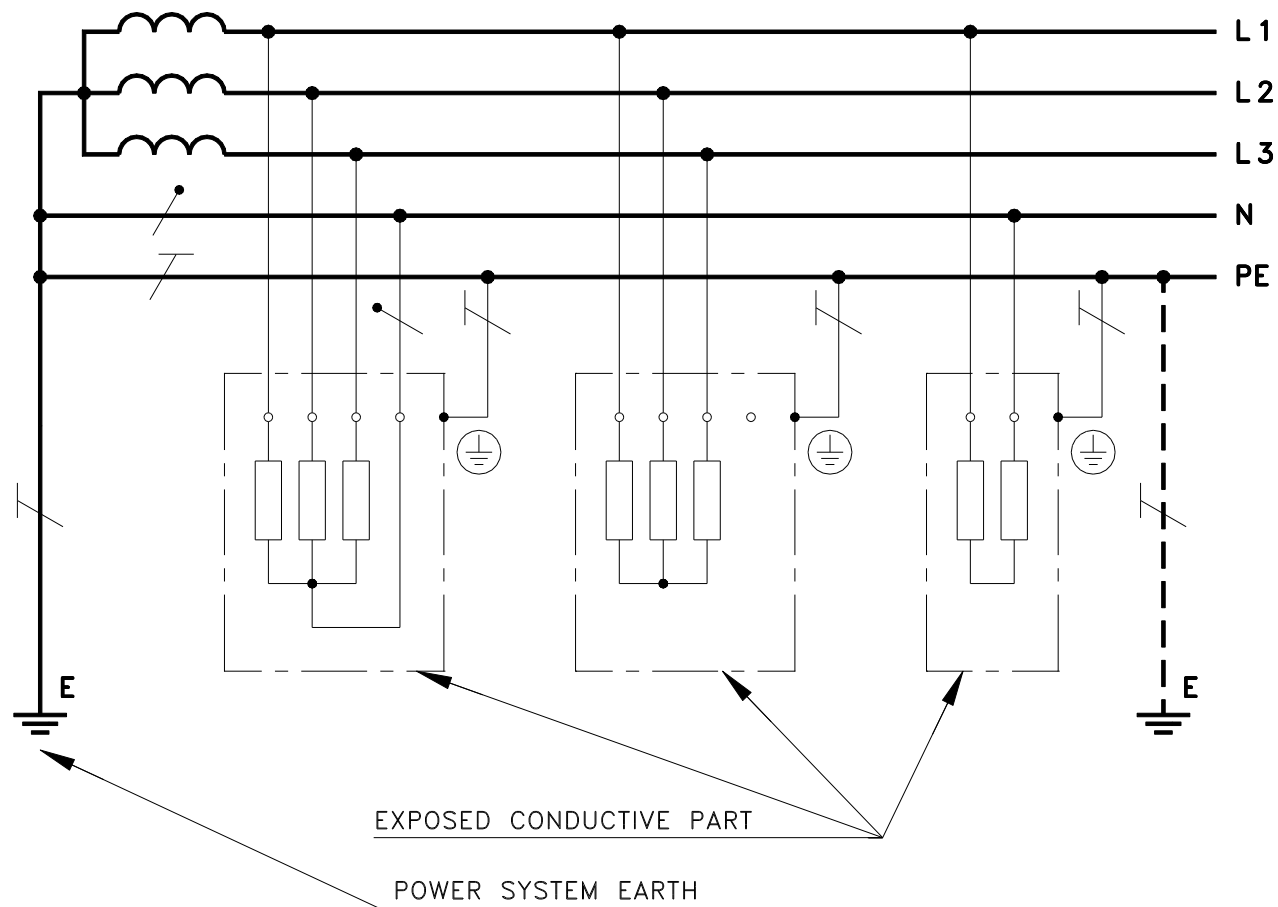


Characteristics of equipment according to the classification











	Class 0	Class I	Class II	Class III
Principal characteristic of the equipment	No means for protective conductor	Protective conductor (PE) means are provided	Additional insulation and no means for protective conductor	Designed for supply at safety extra-low voltage (SELV)
Precautions for safety	Earth free environment	Connection to the protective conductor	None necessary	Connection to safety extra-low voltage
Usual symbols (according to IEC 60417)	No symbol			
Application in installations	In non-conducting locations according to IEC 60364-4-41	With protective conductor (PE) or PEN conductor	General application	With SELV circuits



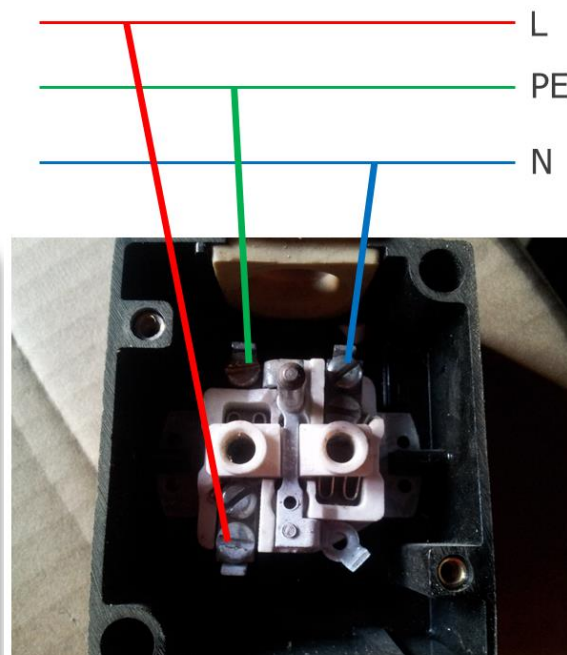
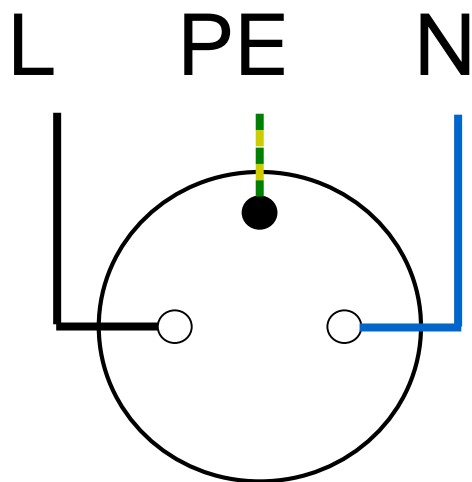
TN-S system



Designation and identification of conductors

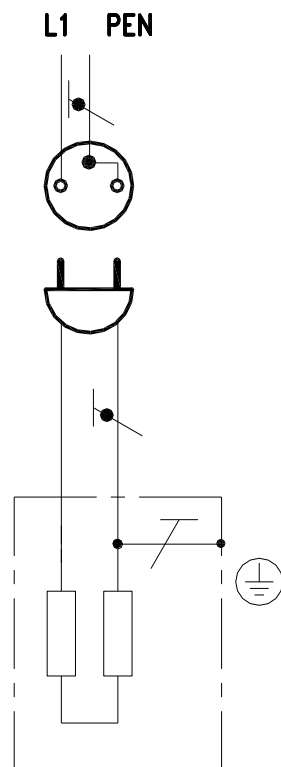
Designation of conductors	Identification			
	Alphanumeric notation	Colour	Colour in Czech Republic	
Supply a.c. system	Phase 1	L1	Not specified	
	Phase 2	L2	Not specified	
	Phase 3	L3	Not specified	
	Neutral	N	LIGHT BLUE	
Equipment terminal a.c. system	Phase 1	U	Not specified	
	Phase 2	V	Not specified	
	Phase 3	W	Not specified	
Supply d.c. system	Positive	L+	Not specified	
	Negative	L-	Not specified	
	Mid-wire	M	LIGHT BLUE	
Protective conductor		PE	GREEN-AND-YELLOW	
Earthing conductor		E	Not specified	
Noiseless (clean) earth		TE	Not specified	
PEN conductor		PEN	GREEN-AND-YELLOW with LIGHT BLUE markings or LIGHT BLUE with GREEN AND YELLOW markings	 

Socket outlet 230 V, 50 Hz, TN-S (Czech Republic)



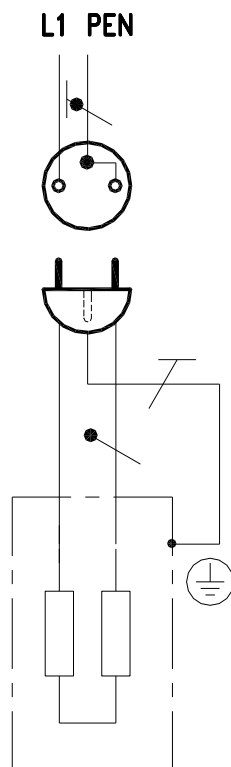


Single phase devices



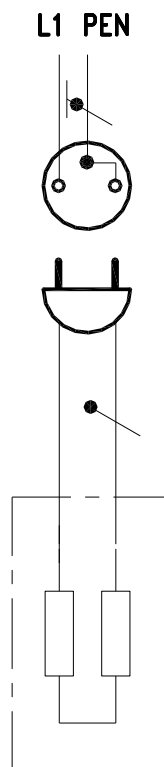
a)

FORBIDDEN



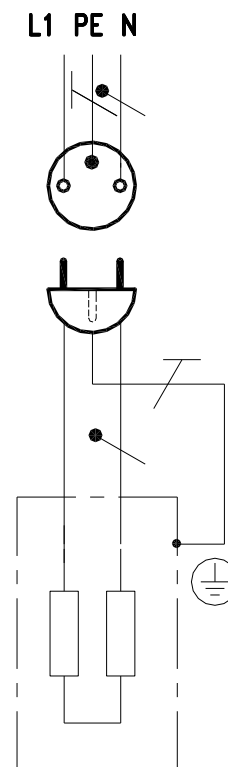
b)

Class I



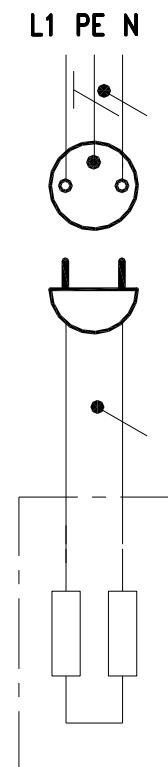
c)

Class II



d)

Class I



e)

Class II

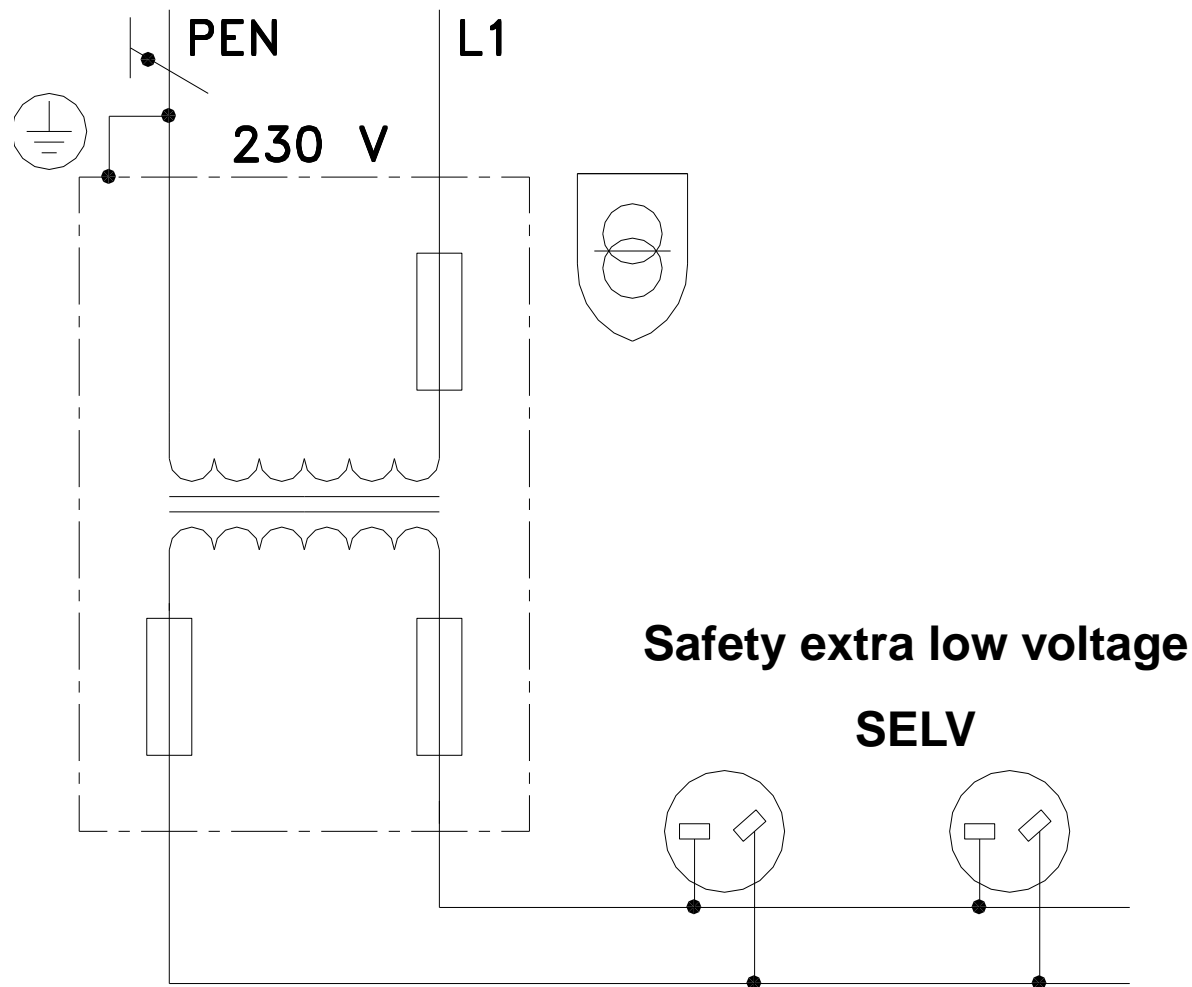
TN-C

TN-S

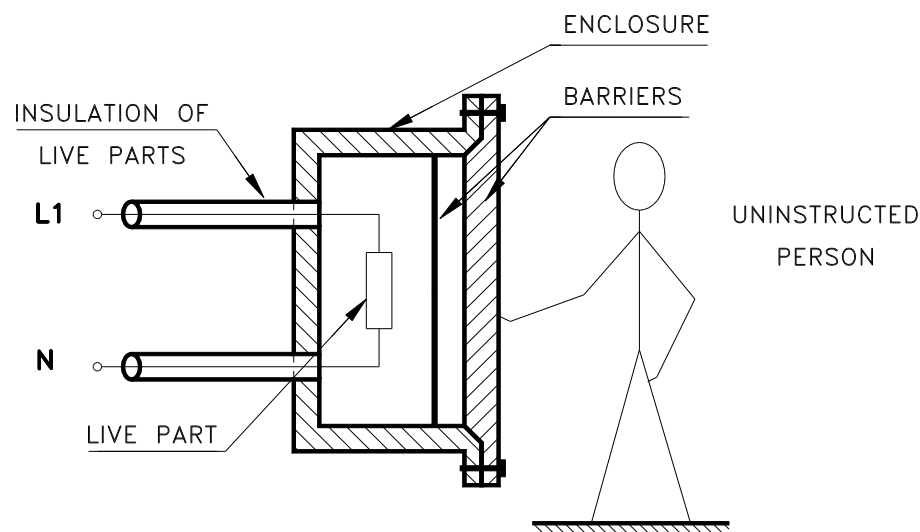
Survey of the measures for protection against electric shock

Group	PROTECTION against	Principle
1	both DIRECT and INDIRECT CONTACT	Safety Extra Low Voltage at live parts does not cause hazardous touch current – Class III equipment
2	DIRECT CONTACT (BASIC PROTECTION)	To limit (disconnect) the touch current in the case of contact with live parts
3	INDIRECT CONTACT (FAULT PROTECTION)	To limit the touch current in the case of contact with accessible conductive parts – Class II equipment
		To limit duration of touch voltage at exposed conductive parts by automatic disconnection – Class I equipment

Protection by safety voltage



Basic protection



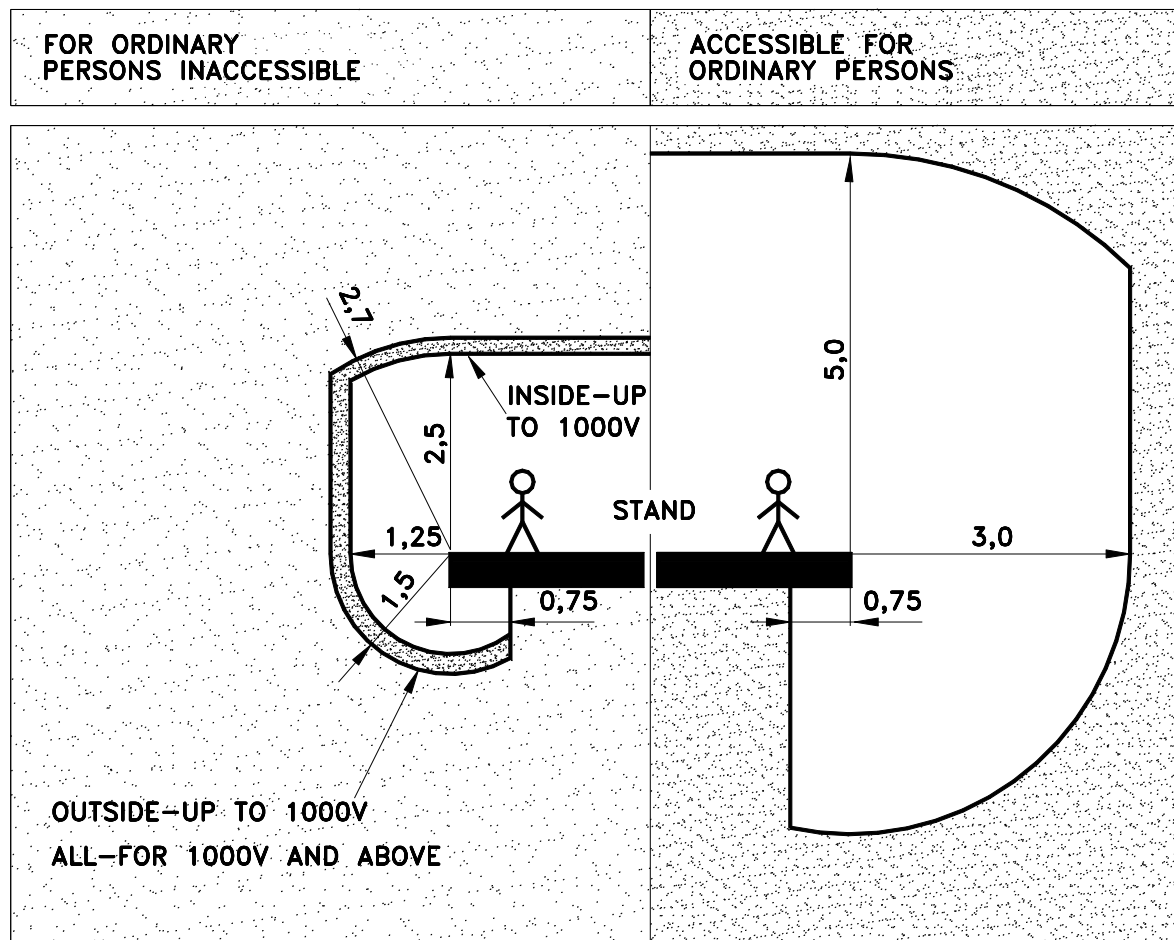
Protection against direct contact.

Protection in normal service.

Basic protection.

Protection by insulation of live parts, protection by barriers and enclosure,
- to prevent any contact with live parts.

Protection by placing out of reach



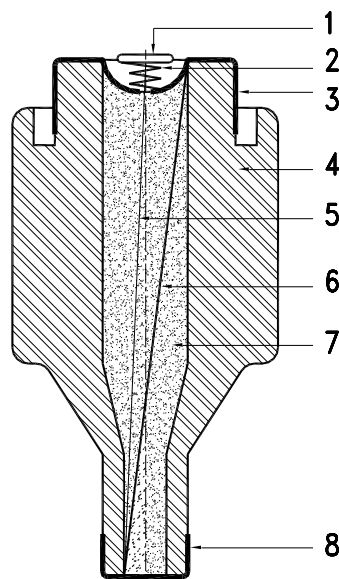
Protection by placing live parts out of reach - zones of arm's reach under different conditions

Protection by automatic disconnection

Over-current protection:

a) Fuse

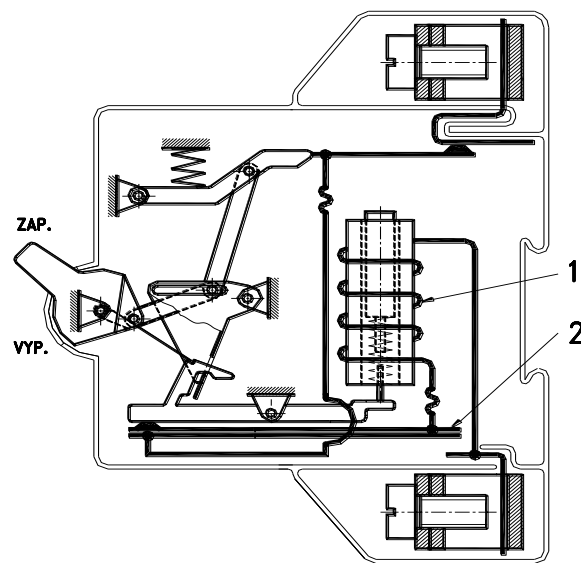
b) Circuit breaker



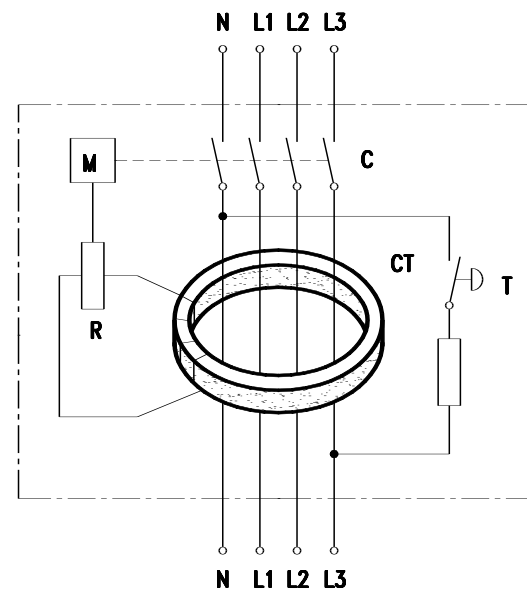
a)

Residual current protection:

c) Residual current protective device

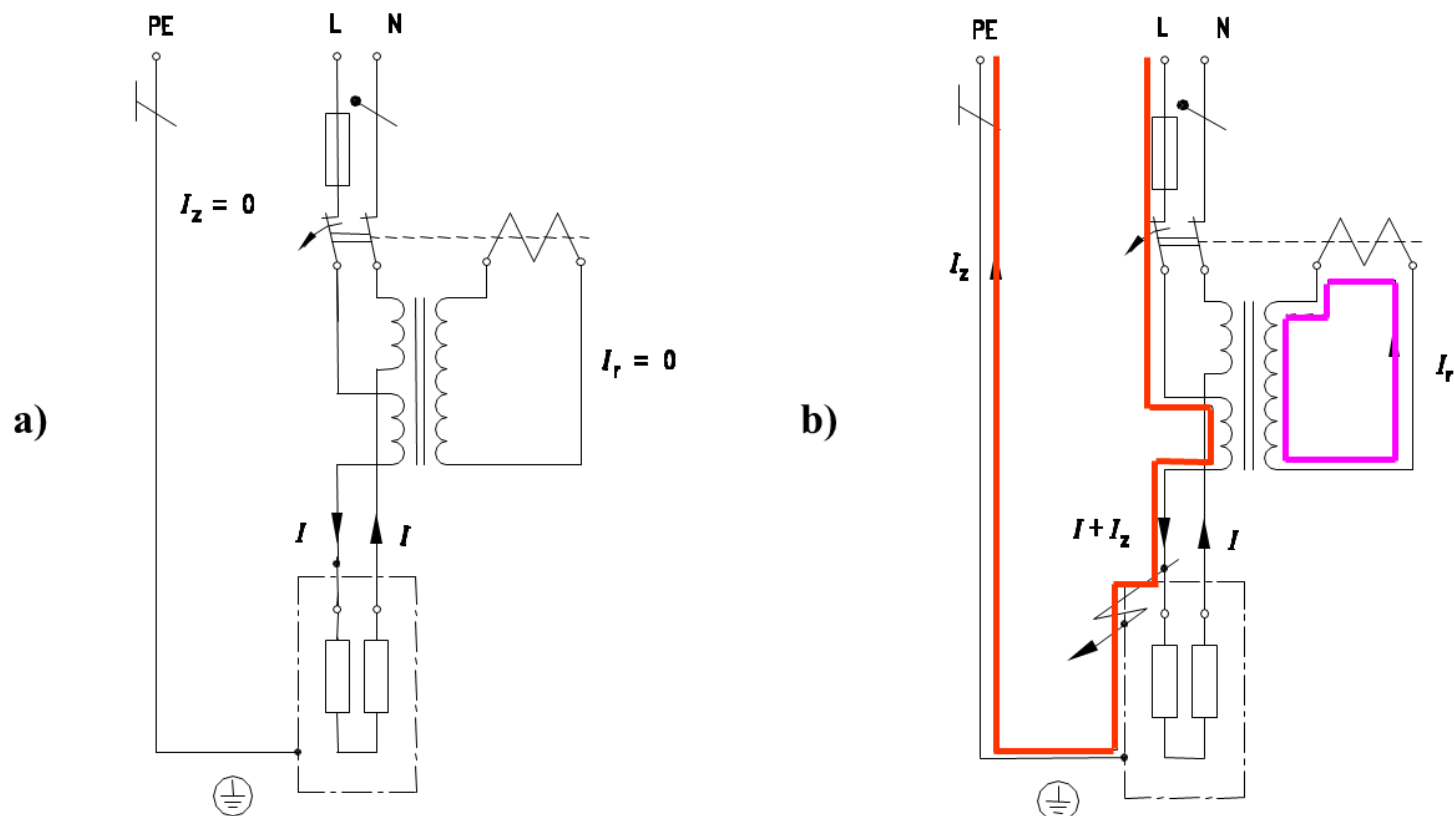


b)



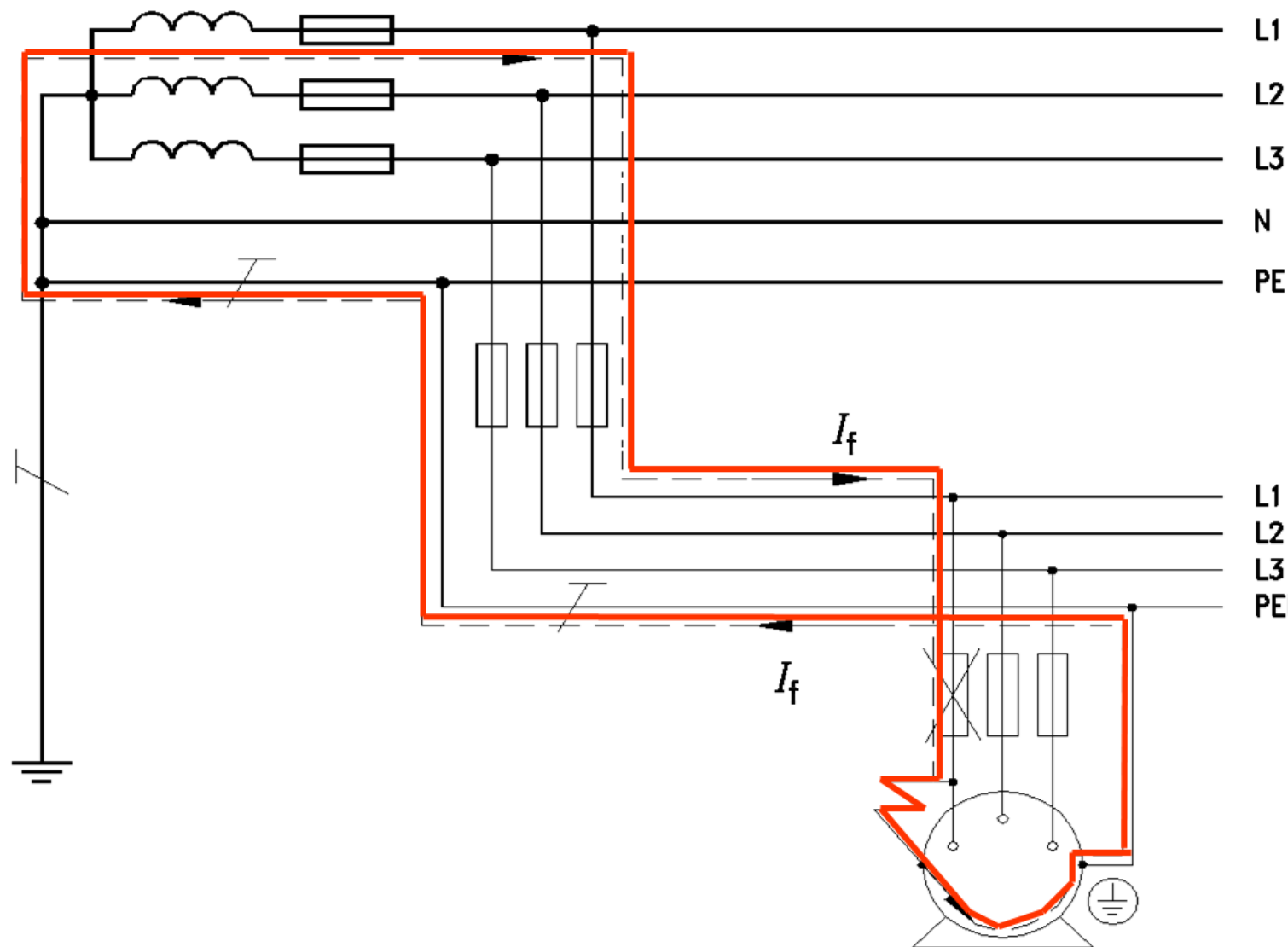
c)

Residual-current protective device



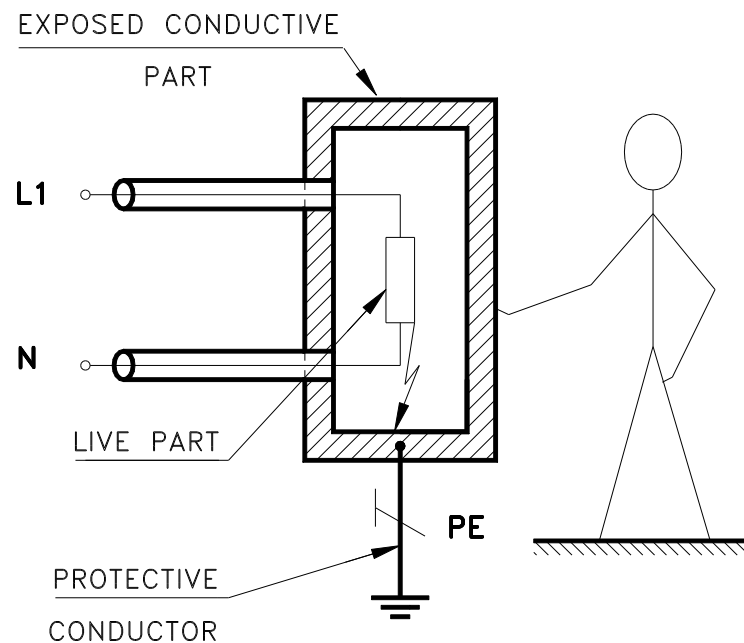
- a) Normal conditions
- b) Fault conditions (I_z ... residual leakage current, I_r ... current in the sense coil; the sense circuitry causes disconnection of the protected device)

Fault loop in TN-S system





Fault protection



Indirect contact and protection in case of fault

First aid treatment of the electric shock

There are two steps of the first aid treatment in case of injury caused by electric current:

- Technical assistance
- Medical part

Technical assistance – disengagement of the afflicted person from the electric circuit is following:

- a) by switching of the electric current
- b) by replacing conductor with an appropriate non-conductive object
- c) by pulling the afflicted person away
- d) by breaking off the conductor

Medical part – first aid treatment

- a) state of health examination
- b) first aid treatment- cardiopulmonary resuscitation
- c) to call for a health service
- d) to inform the person responsible for the workplace

Cardiopulmonary resuscitation contains:

Artificial respiration (by mouth – to - mouth method, by T-tube)
Indirect heart massage

Automated external defibrillator (AED)

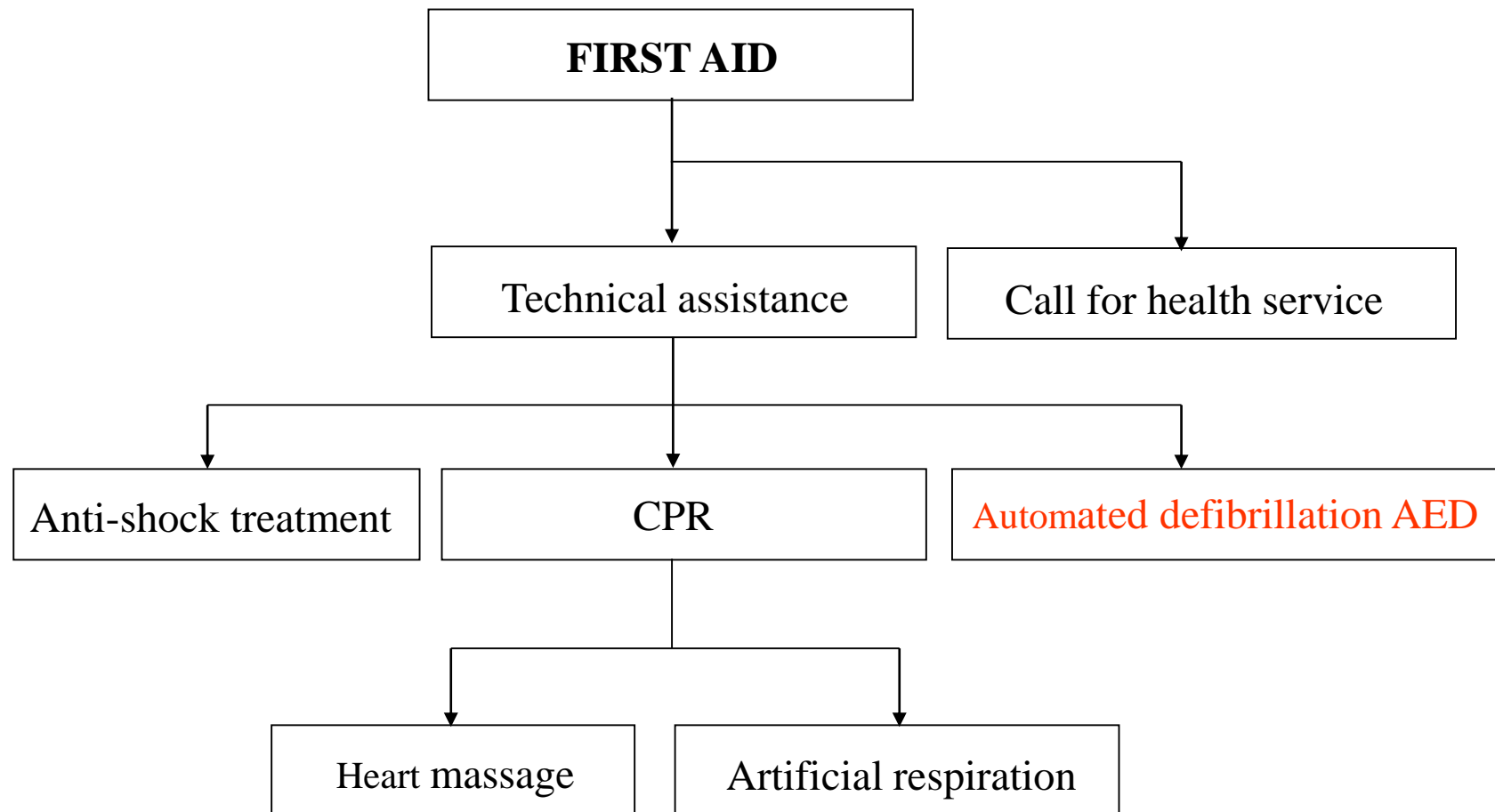


electrodes



AED is a portable electronic device that diagnoses and treats **cardiac arrest** by re-establishing an effective heart rhythm. This treatment is called **defibrillation**, which applies an **electric shock** to the entire **heart muscle**, uniformly clearing the electrical activity of the heart, hopefully allowing it to resynchronize.

First aid classification





Emergency calls

Ambulance	155
Fire Brigade	150
Police – emergency	158
Municipal Police	156

Instructions to the test

The filled form of the test is **fully official document** and it is archived.

The test has a format which is a modification of multiple-choice test.

The correct comprehensive answer on given question is represented by selection from the **list of partial answers**.

Two types of errors are:

when incorrect partial answer is marked

or

when marking of correct partial answer is missing.

At least one incorrect answer and at least one correct answer exist for every item of the test.

The task is: identify **all correct (best) partial answers** from the list of partial answers given.

Maximum of **5 errors** is allowed.



CTU – FACULTY OF ELECTRICAL ENGINEERING

SAFETY IN ELECTRICAL ENGINEERING FOR A BACHELOR'S DEGREE

Written examination: Safety rules for operation of and for work on electrical equipment and installations (Decree No. 50/78)

School year: 2018/2019

Study program: _____

Semester: _____

Study group: _____

First name and SURNAME: _____
(block letters)

I declare that I was informed about and become acquainted with safety rules for the operation of and work on electrical equipment and installations, according to the requirements of Czech standards ČSN EN 50191, ČSN 33 2000, ČSN EN 50110-1 ed.2 mentioned in the lecture notes of

Introduction to Electrical Engineering (2011).

I confirm that I was instructed and that I understood to it.
In proof of it I answer the following (check) questions on my own.

Date: _____

Examiner

Signature of examined person

Date of birth

Note: 1. Carefully fill in the above-mentioned data.
2. Mark the answer you consider to be right with:



(filled square)

correct answer



(empty square)

wrong answer



ALTERNATIVE E 043

A3) The highest safety limit of durable electric current passing through the human body is:

- | | |
|---|--|
| <input type="checkbox"/> direct current 10 mA | <input type="checkbox"/> direct current 30 mA |
| <input type="checkbox"/> alternating current 3,5 mA | <input type="checkbox"/> alternating current 10 mA |

B3) For designation of the insulation of protective conductor is used colour:

- | | | |
|-------------------------------------|------------------------------|---|
| <input type="checkbox"/> light blue | <input type="checkbox"/> red | <input type="checkbox"/> the combination green and yellow |
|-------------------------------------|------------------------------|---|

and for identification of protective conductor is used letter:

- | | | |
|------------------------------|----------------------------|-----------------------------|
| <input type="checkbox"/> PEN | <input type="checkbox"/> N | <input type="checkbox"/> PE |
|------------------------------|----------------------------|-----------------------------|

C3) The highest permissible touch voltage in usual conditions (dry) is:

- | | |
|---|---|
| <input type="checkbox"/> 12 V for d.c. current. | <input type="checkbox"/> 12 V for a.c. current |
| <input type="checkbox"/> 50 V for d.c. current | <input type="checkbox"/> 50 V for a.c. current |
| <input type="checkbox"/> 120 V for d.c. current | <input type="checkbox"/> 120 V for a.c. current |

D3) Protection against indirect contact may be achieved by:

- | | |
|--|--|
| <input type="checkbox"/> electric separation | <input type="checkbox"/> barriers and enclosures |
| <input type="checkbox"/> automatic disconnection of supply | <input type="checkbox"/> double insulation |

E3) Instructed person is:

- ☐ a person with relevant education and experience to enable him or her to avoid dangers which electricity may create
- ☐ a person without any electrical qualification
- ☐ a person adequately advised or supervised by skilled persons to enable him or her to avoid dangers which electricity may create

F3) Socket outlet (receptacle) 230 V, 50 Hz in TN-S network system. Neutral conductor (view from the front) is connected to:

- ☐ the terminal of left socket contact
- ☐ the terminal of the protective pin
- ☐ the terminal of the right socket contact

Protective pin is positioned:

- | | |
|-------------------------------|-------------------------------------|
| <input type="checkbox"/> down | <input type="checkbox"/> on the top |
|-------------------------------|-------------------------------------|

Phase conductor is connected to:

- | | |
|--|---|
| <input type="checkbox"/> the left terminal | <input type="checkbox"/> the right terminal |
|--|---|

G3) In the case of electric shock it is first of all necessary:

- ☐ to start artificial respiration
- ☐ to call for doctor
- ☐ to remove the afflicted person from the range of the current

Safety rules – 1

SAFETY RULES

(laboratory K13114)

Entry into the laboratory is permitted only under the supervision of the teacher.

- a) Professional level of students in 1st and 2nd year of study is "instructed person".
- b) The teacher appoints, for every exercise, one temporary leader for each working group. This leader is responsible for giving instructions. Students must conduct themselves in the laboratory according to the instruction given to them by the teacher and their temporary group leader.
- c) Students are obliged to acquaint themselves in the use of all laboratory equipment and measuring instruments before they enter the laboratory.
- d) Students must have the permission of the teacher before carrying out any electrical operation. Only the teacher is allowed to switch the control panel ON.
- e) Moving, connecting or disconnecting the equipment and instruments is permitted **only when no voltage is connected**.
- f) It is strictly forbidden to wear metal chains and rings as well as to wear shorts and shirts with short sleeves.

Safety rules – 2

- h) It is necessary to maintain a safe distance from elements with voltage applied to them, and it is forbidden to touch non-insulated parts which have a voltage applied.
- i) All work in the laboratory can be undertaken only under supervision.
- j) Students are obliged to watch equipment and instruments, and in case of danger they must switch the control panel OFF by means of the BIG RED BUTTON.
- k) Students of one working group must remain at their designated work-station; they are not allowed to go throughout the laboratory. Students must have the permission of the teacher to approach rotating parts of machines.
- l) If the student feels tired or ill or has some other handicap, he must inform his teacher in good time, and he **must not work** on the electric equipment.
- m) To leave the laboratory is possible only after fulfilling the given task, bringing the work-station into its initial starting state, and with the permission of the teacher.