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## DEPARTMENT OF FOREIGN LANGUAGES

ÚSTAV JAZYKŮ

## ELECTRICAL SHOCK: FIRST AID

PRVNÍ POMOC PŘI ÚRAZU ELEKTRICKÝM PROUDEM

### BACHELOR'S THESIS

BAKALÁŘSKÁ PRÁCE

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## Bakalářská práce

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Cílem bakalářské práce je vytvořit anglicky psanou příručku na téma první pomoc při úrazu elektrickým proudem. Tato příručka by měla obsahovat: postup záchranných prací, přivolání odborné pomoci, eliminace možných rizik. Důraz bude kladen na vlastní text práce.

### DOPORUČENÁ LITERATURA:

[1] American academy of orthopaedic surgeons (AAOS), America college of emergency physicians (ACEP), ALTON L. THYGERSON. First Aid, CPR, and AED Essentials. Wall Street, Burlington: Jones & Bartlett Learning, 2011. ISBN 978-443-5000.

[2] KADLEC, Radim a Miloslav STEINBAUER. Bezpečná elektrotechnika. Brno, březen 2015. Skripta. Vysoké učení technické, FEKT.

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## **ABSTRAKT**

Cílem bakalářské práce je seznámení čtenáře s problematikou úrazu elektrickým proudem a následnou první pomocí. Čtenář bude nejprve seznámen s celkovou problematikou první pomoci, poté získá informace týkající se různých nebezpečných prostředí, ve kterých může s elektřinou přijít do styku. Část bakalářské práce je věnována problematice elektrické bezpečnosti, s níž by měly být seznámeny všechny osoby jakkoli používající elektrická zařízení. Hlavním cílem práce je lepší pochopení problematiky první pomoci po zásahu elektrickým proudem a nabytí základních znalostí z oblasti elektrické bezpečnosti, za účelem předcházení možným úrazům.

## **KLÍČOVÁ SLOVA**

První pomoc, Úraz, Elektrický proud, Zraněná osoba, Nebezpečná prostředí, Úraz elektrickým proudem, Vyprošťování zraněné osoby, Způsoby transportu

## **ABSTRACT**

The goal of this bachelor thesis is to introduce the problematic of Electric Shock with the subsequent First Aid. Firstly, the reader will be introduced to the problematic of the First Aid. Secondly, the reader will be informed about various dangerous environments and possible causes of treatment. The part of the thesis focuses on electrical safety. An individual who uses electric devices should be familiar with electrical safety to prevent risks of electrocution. The primary goal of the thesis is a better understanding of the topic First Aid after Electric shock and an acquisition of basic knowledge from electrical safety to prevent possible injuries.

## **KEYWORDS**

First Aid, Treatment, Electric current, Injured person, Dangerous environments, Electrical shock, Electrocution, Extrication of an injured individual, Transport methods

## **PROHLÁŠENÍ**

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V Brně dne .....

.....

(podpis autora)

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V Brně dne .....

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# 1 INTRODUCTION

This bachelor thesis deals with the First Aid, especially First Aid after electrocution. Nowadays electricity is spread all around the world. The majestic power also creates various situations, in which a person has to know how to act. A similar situation is in traffic when a driver is instructed about First Aid before obtaining a driving licence.

An individual who works or just using electricity has to be instructed about basic facts, how to work with electricity, and First Aid when a failure occurs. Each of us can be quickly forced into a situation when someone in surroundings will immediately need an effective aid. When a person has to confront with really critical, life-threatening accident, it is necessary to act quickly because each minute decreases a chance of survival. It is well-known that even First Aid accomplished by a non-professional might save the life of the injured person. An enormous number of people are afraid to perform First Aid because they do not want to harm the injured person more than he or she is.

The profession of electricians belongs to dangerous one, including high risks of injury caused by electric current. It is not possible to say that only electricians' work in a dangerous environment. Each person who uses electrical appliances has to be prepared for the First Aid. Considering this fact the bachelor thesis will be written in such a form as a handbook with the goal to comprise all the essential facts about First Aid and electrical safety. The writer will write a manual that can be useful in cases of danger with the aim of the most important features. The thesis will include two major parts – First Aid and electrical safety. In most cases injuries can be prevented by knowledge of electrical safety.

The goal of this bachelor thesis is to introduce this topic to persons who work with electricity and do not know how to perform First Aid instinctively with respect to various conditions and different types of impact.

## 2 DEFINITION OF FIRST AID

Definition of First Aid is the most important for this bachelor's thesis. The First Aid is defined as all the basic precautions that in the state of sudden danger or injury limit consequences of this threat or disability.

Each citizen of the Czech Republic is obliged to provide First Aid under all circumstances that will not harm his life. A person who will not provide First Aid can be punished by imprisonment of up to two years. All details are included in the criminal code under paragraph 150.<sup>1</sup>.

If it was not possible to provide First Aid, the criminal code will not prosecute a person only in case the rescuer should be forced into any specified conditions that will endanger his life.

For emergency service, it is not possible to be in critical situations immediately on the spot. There are serious conditions (traumatic and atraumatic) when First Aid of high quality make decisions about life and death. The essential procedures for providing First Aid are in no way complicated. The basis is to have knowledge of these procedures and to be able to know how to use them in time.

First Aid can be divided into two groups which are on the same importance level. It is the medical First Aid and the technical First Aid. The Medical First Aid is First Aid provided to injured persons after the failure of their health.

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<sup>1</sup> § 150 Neposkytnutí pomoci

(1) Kdo osobě, která je v nebezpečí smrti nebo jeví známky vážné poruchy zdraví nebo jiného vážného onemocnění, neposkytne potřebnou pomoc, ač tak může učinit bez nebezpečí pro sebe nebo jiného, bude potrestán odnětím svobody až na dvě léta.

(2) Kdo osobě, která je v nebezpečí smrti nebo jeví známky vážné poruchy zdraví nebo vážného onemocnění, neposkytne potřebnou pomoc, ač je podle povahy svého zaměstnání povinen takovou pomoc poskytnout, bude potrestán odnětím svobody až na tři léta nebo zákazem činnosti.

[19]

**The Medical First Aid can be divided in:**

- First Aid (Pre-medical, provided by a layperson) – this is First Aid provided by the informed layperson, mostly with only the essential aids (First Aid kit, etc.). This First Aid is crucial in life-threatening situations.
- First medical help – this kind of First Aid is provided by the doctor or by other medical officers before and during the transport of the injured person for further medical care.
- Professional medical help – this kind of medical help is provided by specialised departments of hospitals (surgery, internal medicine, children, etc.)
- Specialised professional medical help – this kind of medical help is provided by specialised hospital department in case it is required by the patient's condition (Traumatology, burn centres, cardiac surgery, neurosurgery, etc.). [19]

**The technical First Aid:**

- The goal of the technical First Aid is to eliminate the causes of the accident and to create the basic conditions for providing the medical First Aid.
- This kind of help comprises emergency care that is performed by members of the Fire department, the Mountain rescue service, the Water rescue service, or by any other emergency services.

**2.1 Who needs First Aid?**

An accident can happen anytime and anywhere. The goal of the rescuer is to keep calm and decide what exactly happened. We might recognise that something happened from unusual noises, screams, odours and from many behaviours that differ from the normal – for example:

- Unusual noise – from the definition of the word noise it is possible to realise that unusual noise is something that is not usual for surroundings. Unusual noise is loud, unexpected and unpleasant. The unpleasant sound can be created by the detonation of bombs, gunshot, etc.
- Screams, moaning, calls for help – If someone will hear screams, calls for help or cry, it is obvious that a person who yells (for example) may be in danger.
- The other examples of unusual perception are as follows: Breaking glass, a change in the sound made by machinery or appliance, strange silence, unusual sights such as downed electrical wires, a person lying motionless, sparks, smoke or fire.

- 
- When a person can recognise unusual odours, it can also be very helpful. Strange odours are stronger than usual, unrecognisable, and inappropriate.
  - Sometimes it is possible to identify when the help is needed from unusual appearances or behaviours. The example of unusual appearance is unconsciousness, confusion, drowsiness, trouble breathing, sudden collapse, slip, or fall.

If circumstances are the same as it is described above, someone will probably need the help. The most important thing is that the person has to realise quickly what exactly happened, decide how to help and what to do. There are many alternatives how to help, but the most important fact is that that the rescuer has to act immediately.

When there is someone around who can help, the person who is going to resuscitate has to choose someone specific from bystanders and ask them for help. In each case, it is better to act when a rescuer is not alone. Always it is better to instruct them to call for the rescue service.

## **3 DANGEROUS ENVIRONMENTS AND POSSIBLE CAUSES OF INJURY**

During a regular usage of electrical appliance, human and livestock must be protected from the dangerous effects of electric current. For the purpose of protection in terms of dangerous contact, voltage is divided by voltage levels:

- Safely low voltage
- Dangerous voltage

Injury caused by electrical appliance may be due to:

- Direct contact with electrical appliance by dangerous voltage.
- Indirect contact with electrical appliance which can create a dangerous voltage in the case of failure.
- Electric sparks or discharge from electric part of the equipment flash over the human body.

This category also contains injuries caused by flash.

- Influence of magnetic or electric field.
- Heat or other radiations.
- Other (shock, fall)

Areas are divided into three groups regarding the risk of the electric shock. This shock can occur during any operation of electrical equipment.

- Normal areas
- Hazardous areas
- Especially dangerous areas

### **3.1 Normal areas**

Normal areas are spaces, where the usage of electrical appliance is considered as safe. [5] In those spaces, there are no external influences. Due to the fact that in those areas there are no external influences, there is not an increased risk of electric shock.

The other examples of those areas can be standard living spaces or offices including dry, warm and non-conducting ambient.

### 3.2 Hazardous areas

Hazardous areas are those, where external influences create a permanent or temporary risk of electric shock. Those spaces comprise cold, humid and conductive ambient.

An example of hazardous areas are outside spaces that are not protected from atmospheric influences, spaces in the industry containing mechanical beats, vibrations and spaces containing any external conductive parts – for instance, hospitals or care facilities. [5]

### 3.3 Especially dangerous areas

Especially dangerous areas are those, where the external influences or unusual circumstances – or a combination of both of them creates especially dangerous conditions for electric shock (permanently increased the risk of injury – heat, conductive vicinity). The limits of safe low voltage with respect to the division of space are included in Table 1.

Especially dangerous areas include condensed or splash water with active corrosive ingredients, vibrations from heavy industry, specific health areas, fire hazard zones, or agricultural buildings with stalled cattle. [5]

Space	During touch of parts/ during operation	Safe low voltage of live parts (V)	
		Alternating <sup>1)</sup>	Direct <sup>2)</sup>
Normal	conducting part	50	100
	non-conducting part	50	120
Hazardous <sup>3)</sup>	conducting part	25	60
	non-conducting part	50	120
Especially dangerous <sup>4)</sup>	conducting part	12	25
	non-conducting part	25	60

1. The value of nominal effective voltage has to be set in given range in order to not exceed the given value. The non-sinusoidal maximum value is not yet established.
2. DC voltages are without a ripple.
3. If the conditions (that determine or influence the risk of injury by electric current) require changing the value of safe low voltage, it can be according to the given appropriate standard specified differently.
4. If it is not stated differently in individual provisions.

*Table 1 - The limits of safe low voltage with respect to the division of space [7]*

### 3.4 Insulation of electric parts

Parts of electric devices that transmit electric currents have to be insulated. Insulation may be removed only by its destruction. Insulation that will be applied to the electric device has to be constructed in accordance with specific standards for electrical equipment. Other devices must consist of insulation that is capable of withstanding a stress that arises from various influences – for example mechanical, electrical, chemical and thermal influences. Paint is not supposed to be a sufficient isolation to provide protection from the danger of electric current during normal working operation.

In the Czech Republic, the use of electrical devices of the class 0 is not allowed. The class 0 means that device contains the basic insulation without any additional protection.

#### **Insulation of electric devices has to satisfy the following requirements:**

- a) **The basic insulation** of the electric device has to be designed for nominal insulation voltage that was determined for a particular device. The designer of the insulation of the electrical device has to take into consideration overvoltage, which can occur. Any electrical component connected between conductive parts that are supposed to be insulated has to be designed to withstand the same stress as electrically active parts. The basic insulation has to be created to provide reliability of the electric device and also provide reliability of protection against electric current. All conductive parts that are not separated from electrical components by using at least basic insulation have to be considered as electronic parts.
- b) **The additional insulation** of the electric device has to be constructed for at least the same stress as for the basic insulation. The insulator used, the degree of contamination, mechanical stresses due to temperature and environment may be different from the basic insulation.
- c) **The doubled insulation** has to guarantee that whichever failure of the basic insulation or the additional insulation will not exacerbate the properties of the remaining parts of the doubled insulation. Any electrical component connected between conductive parts which must be separated by double insulation has to be in compliance with requirements for the protective impedance.
- d) **The reinforced insulation** has to be designed for the insulation of nominal voltage that is set for circuits whose creepage distances are at least equal to the sum of creepage distances of the basic insulation and additional insulation. It is necessary to

specify the insulation requirements (insulator, creepage distance, and clearance distance), with respect to the degree of pollution. The reinforced insulation has to be capable of withstanding the overvoltage that was determined for the next higher overvoltage category than those specified for the basic insulation. Any electrical component that is connected between the conductive parts (those parts has to be separated by the reinforced insulation) has to be in compliance with requirements for the protective impedance.

- e) **The insulation between the circuits** is used in cases when the basic insulation is used between two different circuits. The additional insulation or doubled insulation has to be designed for the higher voltage from the nominal insulation voltages prescribed for those two circuits.
- f) **The clearance and creepage distances** have to be designed to withstand impulse endurance voltage specified for the circuit. Creepage distances have to be designed for the specified insulation tension, especially as shown in Table 1. Those requirements are minimal. Requirements specified by the CSN standard has to be kept. Other solutions are possible only if they are at least equivalent in terms of protection and specified in the CSN.

### **3.5 Safety barriers and protection by position**

A safety barrier is a component which prevents passage into a dangerous area, commonly used to mitigate risk. [12] Using the protective measures such as the Safety barrier or protection by position is possible, but it is necessary to realise that those safety precautions can provide only the basic protection against electric energy or other disturbances. Those protections are determined for usage in such fittings, where the basic protection against fault of the device is not guaranteed. Those protective measures (safety barriers and protection by position) are intended to be used in cases when electric devices are not controlled by skilled or instructed persons, or devices that are not under the supervision of those people.

Safety barriers have to provide protection from the unintentional approach to the active parts that are not protected. They also have to provide protection against accidental contact with the electrically active parts of the electric devices that are operating under voltage during the regular service. Safety barriers that are used for this purpose may be removed without any particular key or instrument. They require protection from unintentional elimination. It is necessary to add that safety barrier is primarily designed to provide protection against accidental contact with live

parts, but not against intentional contact that happened after planned bypassing of the safety barrier.

The Safety barrier protection can be used in two cases. The first case comprises spaces that are accessible to laypersons or employees without the professional competence in electrical engineering by locking a room or using of removable barrier (for example, bars or fence). Those removable barriers are supposed to be sufficiently rigid, high and located at a distance from active parts of the electrical device. The second case comprises spaces that are not accessible to laypersons and employees that are not competent to work on electric equipment. These spaces have to be locked up or enclosed by using ropes, poles, railings, grilles, fences etc. Those protections may be removable.

Objects that will form the Safety barrier have to be mechanically strong and stiff, and must withstand the influences of the given environment. It is recommended to use removable barriers in order to protect a human from contact with live parts of electric devices that are made of insulating material. If the safety barrier is made of a pliable material (e.g. rope), distances from the active parts have to be increased accordingly with the aim to preserve a protection of persons at the largest deflection. The material of barriers has to be non-conductive.

The protection by position means that electrical devices are sited out of reach. This type of protection is separated into two parts - inner devices that operate at low voltage, and devices that are different than inner devices and simultaneously operate at a voltage that is higher than low voltage.

- a) **Inner devices that operate at low voltage:** Inner parts consisting of different potentials that can be touched by a person, have to be sited out of reach of hand. If the ordinarily accessible spot is in the horizontal position and commonly protected by some kind of barrier (for example, a railing or wire mesh), the reach of the hand has to be considered. In the upwards direction the reach of the hand is considered to be 2.5 m from the point P, without considering any other intervening protections. In places, where the manipulation of large or long conductive objects is common, the distances must be increased with respect to the dimensions of the object. The reach of the hand is considered as a touch by bare hands without any tool (for example, a ladder or instruments).
- b) **Devices that are different from low voltage inner devices and simultaneously operate at higher than low voltage:** The same rules as for inner devices holds for places that are unapproachable for laypersons or employees that are familiar with electrical safety. There is only one exception for the reach of the hand rule, which is changed for upwards

direction for inner low voltage devices to 2.7 m from the point P. This topic described more in CSN 33 2000-4-41.

## 4 DISTINCTION OF AN ELECTRIC SHOCK

### 4.1 Injury caused by electrocution

The injured person is stunned by the impact of electric current and usually stays in touch with electric equipment that caused the injury. That is the reason why the process is still ongoing. The impact of electric current causes crumpled muscles and therefore the injured person cannot extricate himself (It is not possible to stop holding the conductor.). [5]

If the accident occurs, the injured person becomes the part of the electric circuit which means that the injured person has to be extricated very carefully in order to protect the rescuer from electric current. Despite the fact that it is necessary to perform extrication quickly, the safe way of rescuing the victim has to be chosen carefully. The way of rescuing has to be selected with respect to given circumstances, position of the victim and parameters of the source. [5]

Simultaneously with rescuing it is necessary to inform an operator of given appliance about origin and location of the injury. The operator has to perform necessary actions that will protect other persons, livestock or property from any other damage. [5]

#### **Practical aids for extricating the injured person:**

- Cutting off the power supply is necessary.
- Interrupt the electric current.
- Use tow movement to get the injured person to a secure place – this topic is more described in chapter 7.
- Interrupt electric conductor that is in touch with the injured person, for example, using a stick that is not made of electrical conductor.

#### **Injury caused by electric current differs from electric discharge in consequences:**

- The low voltage current can cause heart rhythm disorders, which may occur with time delay.
- The voltage lower than 1000 V leads mostly to cardiac arrest or heart rhythm disorders.
- High voltage leads to respiratory failure which is usually the result of suffocation. In the first phase, the breathing is retained, but it is not as effective as in the normal state.

- The occurrence of convulsions may prolong a contact of the injured person with the conductor. This leads to a break or crack in a bone, a rupture of a muscle or in the tendon. [2]
- High voltage current creates heavy and extensive burns of tissue.
- The electric shock can cause other injuries.

## **4.2 Injury caused by the electric discharge**

The injury caused by the electric discharge occurs very quickly. Thus, the injured person does not stay in touch with the electric device. Immediately after seeing the injured person, it is necessary to decide whether there is a possibility of another electric discharge, and if it is safe for the rescuer to provide first aid. Electric devices that operate at high voltage, very high voltage, or at extra high voltage are not safe for the rescuer due to the possibility of occurrence of another electric discharge. To prevent the occurrence of electric discharge, it is necessary to turn off the electric device and rescue the injured person by using the extrication methods described in chapter 7. The person has to be relocated to a secure place. [5]

### **Consequences of the electric discharge:**

- Breathing and heartbeat can be affected.
- Even if the amount of energy released is very high, burns of the skin do not need to be extensive or noticeable, but inner organs can be injured.
- The electric discharge of low energy can cause only temporary and slight confusion, muscle weakness, unsteadiness and sometimes irregular pulse.

### **4.3 Injury caused by a flash of lightning**

The injury caused by the flash of lightning differs from the electric discharge in the value of current and voltage that passes through the body. There is a high risk of injury not only during a thunderstorm, but also persons who are close to the spot that was hit by the lightning may be in danger. Lightning can cause explosions or fire, but the indirect strike is also dangerous because flash creates its own electric current that flows in all directions and simultaneously creates the step voltage.

- The direct hit from the main flash is mostly fatal. From the statistic that is on a web page National Geographic News, about 10 percent of lightning-stroke victims are killed, and 70 percent suffer serious long-term effects.[22]
- A burn of the tissue can appear on the spot, where is the output and the input of the current that passes through the body. The burn can be in the range from first to third-degree burn.
- The paralysis of nerves and muscles may appear. The paralysis usually disappears without any serious consequences in hours or days.
- The current can damage the brain, sense of sight or hearing.
- The pulmonary arrest and the cardiac arrest belong among dangerous effects of the lightning. [5]

## **5 THE PROCEDURE FOR RESCUING AN INJURED PERSON (BASIC STEPS)**

The procedure for rescuing an injured person is one of the most important steps of the First Aid. The rescuing procedure has to be distinguished carefully with respect to the given conditions and circumstances. The most important thing for a person who is going to rescue someone is to decide whether the conditions for this task are safe. The best way to rescue someone has to be selected with respect to the protection of the rescuer and other persons in order to avoid danger. For selecting the rescuing method, the rescuer has to be familiar with different types of electric shock and decide whether the injured person was injured by electric current, electric discharge or lighting.

When the rescuers realise that the injury was caused by an electric current, they must act under the following conditions consisting of cutting off the source or interrupting the input of the electric current. After that, they must transport the injured person to a secure place as described in chapter 7.

Cutting off the electricity supply is the safest way to protect both – the injured person and the rescuer. It is used preferably in cases when it is possible to perform it quickly and safely without any further harm to the injured person.

If the injured person is in a position, where cutting off the source releases his muscles from convulsions followed by the falling down and inflicting further injury, the rescuer has to ensure that the person will not fall down, or choose a different rescuing method.

If the electric device operating at voltages higher than 1000 V caused the injury, it is necessary to perform any kind of rescue attempt. The rescuer has to keep in mind that a machine can automatically turn ON, even if conditions and situation are not the same as they look when the device is turned on, until someone who is responsible for that machine or has knowledge of it ensures that the machine is terminated. Electric devices that operate at high voltages are designed in such a way that they consist of an automatic system which is able to turn the device ON. [5]

### **5.1 Interrupting the conductive part of an electric current**

Interrupting the conductive part of the electric current belongs to procedures for rescuing the injured person. The method is efficient in cases when it is impossible to cut off the source of

electrical energy due to the time pressure (for example the operator of an electrical machine is not able to halt the operation immediately). Interrupting is also efficient in cases when it will not cause a threat to the person who will perform this task. The method interrupting the conductive part of the electric current is not complicated and it is often-used. Interrupting the power has to be carried out by someone who has sufficient technical knowledge, or it is not possible to consider this device as safe until an authorised person switches the device off.

Interrupting has to be performed using an instrument with sufficient insulation, such as a pair of insulated pliers, and an axe with a wooden handle. After the interruption, it is necessary to prevent from accidental contact of the conducting end device (AC wire) with a broken conductor or a metal frame. [5]

## **5.2 Extrication of the injured person**

Extrication of the injured person is a process that can be used in cases when cutting off the electricity supply is time-consuming, or the rescuer cannot be sure whether the device was securely terminated, or the injured person is not in the safe position with respect to the possibilities of another injury.

The fundamental principle is that the rescuer cannot become a part of an electric circuit by touching a conductor or the injured person. Due to the fact, the direct contact of the rescuer with the body of the injured person, his or her dampish clothes, or even metallic elements is prohibited.

For intervention it is convenient to create improvised insulated platform – the rescuer will stand on it (dry board, box, carpet, tires, etc., according to local conditions). Rescuer's hands have to be protected by proper insulation as much as possible (using gloves, dry clothing, dry towel, etc.). It is also recommended to tow the injured person with one hand only.

If injury was caused by an electric device which operates at voltages over 1000 V, the probability of step voltage becomes dangerous. A person who is going to perform First Aid has to move by small steps only in order to avoid the risk of step voltage. The other rescuing procedures have to be performed in order to overcome the most minor possible potential difference. [5]

### **5.3 Removing the source of the injury away from the victim**

Removing the source of the injury away from the victim is reliable mostly in cases when the creating of the step voltage is dangerous, or as prevention of the automatized launching system which is installed on the device that caused injury.

The source that caused injury can be displaced by using a tool with sufficient insulation. The example of this tool can be a dry wooden stick, rake or rope.

Approach to the source of injury has to be considered with respect to given circumstances and usage of the protective equipment. [5]

## 6 DETERMINE THE EXTENT OF INJURY

### 6.1 Basic principles

The most important for a wounded person is that the rescue operation and the subsequent resuscitation will be performed as soon as possible. Crucial for survival is the amount of electrical current that injured two of the most important vital signs - breathing and heartbeat. Therefore - it is necessary that the first screening tests about the state of the injured person will initially focus on two basic functions regardless of another injury. After stabilisation of the essential vital functions, the rescuer proceeds to deal with the other injuries that are less dangerous for health and life. [5]

Figure 2 illustrates the first screening tests. Firstly it is necessary to stop the bleeding, then proceed in the sequence: head, collarbone, chest, abdomen, pelvis, legs, arms.



Figure 1 - The first screening tests [13]

If the injured person is identified with respiratory arrest and circulatory arrest, it means that the oxygen supply to the tissues is interrupted. It has an impact on the brain tissue. For this reason, the resuscitation must be initiated as soon as possible. Statistically, it is proven that if the resuscitation was started within two minutes – there is a 90 percent chance of survival. If resuscitation started after 4 minutes, the statistical number of rescued persons dropped to 50 percent and after 5 minutes it was only 20 percent. For this reason, the first screening tests of the injured person have to be executed promptly (within 30 seconds), followed by the cardiopulmonary resuscitation (CPR).

## **Commencement and termination of resuscitation**

Regardless of the paragraph focusing on the definition of the First Aid - it is necessary to state again that each citizen of the Czech Republic is obliged to provide First Aid under all circumstances that will not harm his or her life. A person who will not provide First Aid can be punished by imprisonment of up to two years.

The resuscitation does not need to be performed in some cases. The case is only when a body has a post mortem signs as posthumous spots, rigor mortis, when the injury is incompatible with life, if the rescuer will be exposed under threat, or in do not resuscitate state (DNR) that was issued by the medical team.

The resuscitation can be terminated only after restoring of the vital functions, hand-over to a trained First Aid professional or when rescuers are exhausted to continue.

## **6.2 Call the rescue service**

If there are other persons in the surrounding of resuscitation, one of them has to call the rescue service and the second person has to assist. The advantage of calling the emergency service is the fact that it can be called from each mobile phone without inserting a SIM card. Nowadays it is recommended to use speakerphone feature of the mobile phone that allows to communicate with an emergency service dispatcher and simultaneously to perform rescue procedures.

### **Emergency Numbers:**

- **112** - European emergency number in all states within EU
- **150** - Fire Department
- **155** - Emergency Medical Service of the Czech Republic
- **158** – Police Department

An emergency service dispatcher will request information about the situation at the place and where the accident happened. The person on the phone has to say all the information to the dispatcher. The dispatcher will – if necessary – provide information on how to help the injured person until the arrival of emergency service, especially in states of emergency – cardiac arrest, choking, arterial bleeding, but also in the case of a sudden childbirth. The technical equipment of emergency call centres allows passing information to the ambulance crew without interrupting the call with the caller. Thus, while the call continues, the ambulance crew is informed and on way.

A mistake can affect the result of the rescue attempt. There are situations in which a person who is not an experienced expert in medical matters can have problems with solving. There are only two tasks for amateur rescuer – to call the professional support (the rescue service) and to buy a time. The time can be bought not by money, but by real actions. Even if the person is not able to perform demanding tasks, the goal is to maintain the basic vital functions, for example by stopping of massive bleeding. Wrongly informed medical service can result in the decrease of patient's survival chances.

### **6.2.1 The most common communicative mistakes:**

1. The person who speaks with the emergency service dispatcher does not remember the house number or does not realise that the doorbell push button does not contain the name that can serve as a useful assistance for an emergency crew.
2. Occupants of the building do not realise the fact that the door is locked, or the doorbell does not work.
3. The house number is not located at a clearly visible spot, or not even placed at all.
4. If the accident occurred on hardly accessible terrain as forest, field, meadow, etc. someone has to stay on the spot where the exit to the main road is. [5]
5. A person who initiated the call to emergency line hung up the phone before the emergency service dispatcher obtains enough information.
6. The situation and the accident spot was wrongly described.
7. A person is angry, impolite and shouts at the emergency service dispatcher.

### **6.2.2 Quick guide depending upon the situation:**

There are various ways how to react according to the state of the injured person.

1. An individual who is unresponsive to stimuli, breathe with problems, or there is no breathing.
  - a. Firstly is necessary to call the medical service before the beginning of the First Aid.
  - b. Pay attention to “strange” breathing. If the patient is in unconsciousness, breathing is very occasional, coming in gaps or it can be similar to a carp, the patient's medical state has to be considered as a respiratory failure. The check of breathing is illustrated in figure 3.

- c. The cardiopulmonary resuscitation (CPR) has to be initiated. CPR involves 30 chest compressions of adequate depth (at least 5cm but no more than 6 cm) with a rate of 100-120 compressions per  $\text{min}^{-1}$  followed by artificial ventilation by exhaling air into the subject's mouth or nose – two rescue breaths. [14] Rescue breaths may be performed by using even CPR mask or CPR barrier in order to provide protection from transmission of serious diseases.

A similar and simplest method than CPR is called "chest-compression-only CPR". The method is used when the rescuer is unwilling or unable to give rescue breaths. [10] An example of chest-compression-only CPR is illustrated in figure 4.

- d. Resuscitation has to be performed until the arrival of the ambulance crew or until the patient starts to react. Occasional breath during a massage shall not lead to the termination of compressions.



Figure 2 - Check of breathing and perception [13]

2. A person with normal breathing, but without reaction to a stimulus.
  - a. Firstly it is necessary to call the medical service before the beginning of the First Aid.
  - b. Leave the injured person in a position in which he or she was (unless there are no other hazards). Until the arrival of the ambulance crew check if the individual breaths normally.
  - c. If the rescuer is not sure about patient's breathing (that the person stops to breathe normally or completely stops), it is necessary to initiate CPR, see above. [18]

3. A Person with muscle cramps throughout the body
  - a. Call the medical service.
  - b. Let cramps subside and eliminate hazardous objects that can harm the patient's health.
  - c. Never try to open patient's mouth during muscle cramps by any violence and never insert a hand into the mouth in order to take out a tongue.
  - d. The most important is to let cramps subside and check whether the patient breaths normally. If no, tilt his or her head and clean air passages. If it does not help - initiate the CPR.
4. A person who had respiration problems, pain in the chest or is paralysed by the accident.
  - a. Call the medical service.
  - b. The patient has to stay in the position that fits him or her.
  - c. The patient's breathing has to be checked until the arrival of the ambulance crew.



Figure 3 - An example of chest-compression-only CPR [13]

### 6.3 Signs of death

Since a period of dying is differently lasting process, death is not clearly and easily distinguishable from an apparent death. There is a variety of symptoms for a recognition of mortality.

Uncertain signs of death are such symptoms that are usual among the dead, but they can also become visible or noticeable at alive people. Generally, the presence of a particular death sign marks the fact that death is probable but not certain. The uncertain symptoms are as follows: Pallor mortis, Algor mortis, inaudible heartbeat, inaudible breathing, muscle weakness and inconclusiveness of pulse activity. [17]

Definite symptoms of death are such signs, whose presence means a certain death. The definite signs of death are as follows:

- **Livor mortis** – Characteristic by purplish red spots that begin to form about twenty minutes after death from the bottom of the body. Livor mortis is not formed at the spot, where a dead person lies on the mat.
- **Rigor mortis** – Caused by chemical changes in muscles after dead. Firstly at the face, then neck, upper limbs and eventually lower limbs. The full stiffness generally occurs from six to eight hours after death. It lasts for several hours or days and then disappears.
- **Algor mortis** - The temperature of the body decreases during the first four hours after the death. The temperature drops about one degree Celsius hourly at normal room temperature. If the ambient temperature is higher than the body temperature, the change will be positive.
- **Drying of the mucous membranes** - Occurs very soon after death.
- **Putrefaction** – It is one of seven stages of the body decomposition. Firstly it starts from the area around the navel. Since third until the fourth day it is spread throughout the abdomen, then through the chest and limbs. After a week, rot fluids seeps through the skin, on the sides of the trunk are create blisters, filled with greenish fluid that eventually burst. After fourteen days, the skin is completely peeled, hair and nails begin to detach. Gases swell up the body. After six months of the process, soft parts on upper body are missing, only the fibrous tissue remains. [17]

## 7 TRANSPORT OF THE INJURED PERSON

Under normal conditions in the Czech Republic with the coverage of mobile networks and the availability of professional medical services the transport of seriously injured persons is always happening by the Emergency Medical Service. An improvised transport of the injured person can be performed only in case the health of the injured person will not be disrupted.

The injured person cannot be transported by a single rescuer if there is any other possibility, always – if possible – the best way is to wait with the injured person until the arrival of the ambulance crew. Type of the transport varies according to the state of the injured person, amount of rescuers and location of the wounded person. It is necessary to take into consideration a route that has to be surmounted. [17]

Transport of the injured person by a single rescuer can be performed by using various methods that have to be selected with respect to the medical condition of the transported person.

The first and the easiest method of transport is an accompaniment. This method is used in cases when the injury is not serious and the injured person is able to move without any difficulties. This method can be used in cases when injured parts of the body are not necessary to be used for a movement. The example of suitable injury is cut on finger and hand fracture that is not compound (compound fracture).

The second method of transport of the injured person is more difficult than the previous, but it is feasible. The injured person can be dragged by holding clothes, or forearm which is called Rautek's method. The Rautek's method is mostly used for extrication of the injured person.



Figure 4 - An example of Rautek's method [13]

The third and the most difficult method of transport is carrying the injured person. The method is the most difficult because rescuer has to be strong enough and also has to be able to carry the whole weight of the injured person. The injured person can be carried in arms, on back (pack-strap carry or piggyback), or on shoulders. Carrying on shoulders is sometimes referred as Fireman's carry or Fireman's lift because it is widely used by firefighters or soldiers who transport injured or unconscious people away from danger. This method is widely used for long distance transports.



*Figure 5 - An example of the fireman's carry, a method of carrying a person away from a dangerous situation. [9]*

Methods for transport of injured people by two rescuers are similar to Rautek's method and accompaniment. If there is more than one rescuer, it is a significant advantage. Two rescuers are allowed to perform the seat carry method. The seat carry method can be performed by using two (two-handed seat), or four (four-handed seat) hands or by carrying the injured person who will sit on the chair (chair carry).

The four-handed seat technique is efficient for medium distance transports. A person who will be transported by this method has to be able to hold themselves during a transport. Each bearer grasps one of his or her own wrist and the wrist of another bearer, which forms a packsaddle.

The two-handed seat technique differs from the four-handed and thus, it has more advantages. It is efficient to be used for long distance transports. The victim does not need to be able to hold himself because bearers will create a chair. This technique is performed as follows: each bearer passes his arms under the victim's shoulders and knees and grasps the other rescuer's wrists.

## **A Stretcher**

Transport on the stretcher can be divided according to two types – an improvised stretcher and a blanket stretcher. Both types have one thing in common – rescuers have to be sure that the stretcher is all right before loading of the victim. A healthy person has to test the stretcher.

The improvised stretcher can be constructed by using two poles or pipes which are strong enough to withstand the weight of the victim. A load area can be created by using t-shirts, but rescuers shall be careful about giving up clothing. It can affect their health.

The blanket stretcher can be constructed by using two poles or pipes and a blanket that has to be folded over the poles. For constructing the secure and durable stretcher it is necessary to follow the following steps:

1. The blanket has to be placed on the ground.
2. The first pole has to be placed approximately 1 foot from the middle of the blanket.
3. The blanket has to be folded on the short end over the first pole.
4. The second pole has to be placed according to the size of the victim under the blanket.
5. Both halves of the blanket have to be folded over the second pole.



*Figure 6 - A stretcher from blankets and poles. [11]*

The upper limbs of the injured person should be positioned on the chest and fixed to the stretcher – if possible. Feet's of the injured person have to be in the direction of movement, except climbing the hill or stairs. The injured person shall be transported in a horizontal position.

[17]

## 8 FIRST AID KIT

The First Aid Kit is a collection of essential equipment and supplies for use in providing First Aid. There are various types of First Aid kits according to their use – in the car, at home, in the workplace. The content of given First Aid Kit differs according to the specific legislation and regulation that specifies it. In the European Union is the content of First Aid kits specified by the EU 9342/EWG policy. In the Czech Republic is the content of those First Aid kits specified by the regulation no. 258/2000 Coll., 314/2002 Coll., 106/2001 Coll. and 79/2013 Coll.

The content of the First Aid Kit should deflect risk of activity for which is intended, for example workplace, trip, vacation, house etc. The content has to be checked at least twice per year (in the case of occasional First Aid kits it has to be before departure).

The First Aid Kit has to contain only the necessary equipment for providing First Aid. The First Aid Kit cannot be used as a storage of toxic, poisonous and other resembling agents.



Figure 7 - The content of the First Aid Kit, photo by Ivo Chytil

The non-personal First Aid kits have to consist of a diary which is used for documentation of usage, list of emergency and other important telephone numbers.

The standard equipment of the First Aid Kit consists of gloves, CPR mask, bandages, disinfection, clipper and a surgical mask. According to the expected usage, the First Aid kit can be supplemented with a thermometer, tweezers, Paramedic Scissors, and over-the-counter drugs.

A person, who will provide First Aid has to be careful and must not forget to use disposable gloves to provide protection from transmission of serious diseases as AIDS or Hepatitis.

The First Aid Kit should be used after an evaluation of a situation, ensuring safety for both the rescuer and the injured person and after an indicative screening of the injured person with eventual calling the medical help.

The minimal content of the First Aid Kit for four-wheel vehicles in the Czech Republic is specified in the table below:

<b>Item</b>	<b>Amount</b>
CPR mask	1
Tape (roll) (2,5cm x 5m)	1
Triangular bandage (960x1360x960mm)	2
Roll with 1 gauze pad (width at least 8 cm)	3
Roll with 2 gauze pads (width at least 8 cm)	3
Rubber bandage ESCH (60 x 1250 mm)	1
Adhesive bandages (8 x 4 cm)	6
Protection against undercooling, wetness and dirt (200 x 140 cm)	1
Paramedic Scissors	1
Disposable Gloves	1
Shield CPR Barrier (20 x 20 cm)	1
First Aid guide	1

*Table 2 - First Aid Kit equipment [3]*

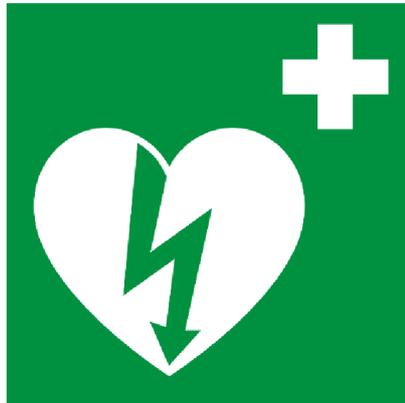
## 9 AED – AUTOMATED EXTERNAL DEFIBRILLATOR

An automated external defibrillator is a device able to analyse an EKG curve. It allows to perform defibrillation safely, without knowledge of concrete steps due to written and sound commands. Nowadays, this device is widely distributed at various places, for example in the Brno, there are 22 spots, where the automated external defibrillator is placed and ready to be used by ordinary citizens – laypersons.

The name of the device completely explains the purpose. The device allows laypersons to provide defibrillation which is the special procedure of life support. This procedure can remove a significant heart rhythm disorder (ventricular fibrillation) leading to a circulatory arrest. [1]

On the assumption that defibrillation will be performed immediately after the accident, there is 94% chance of survival. If defibrillation started after 5 minutes, the statistical number of rescued persons drops to 50% and after 12 minutes it is only 25%. That is the reason why the performance of resuscitation with subsequent defibrillation has to be executed instantly.

The automated external defibrillator is marked by a specific sign that is shown below in figure 8.



*Figure 8 - AED sign [15]*

### 9.1 How to use the automated external defibrillator:

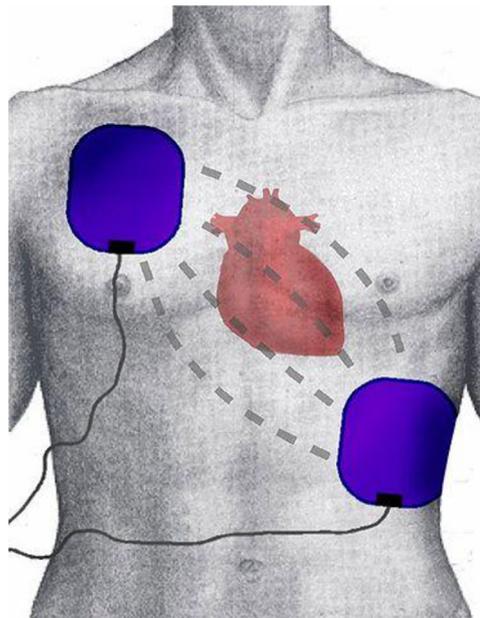
Before the use of an AED, it is necessary to check whether the person who collapsed does not have any objects in the mouth and whether is breathing. After that, the person who is going to resuscitate has to choose someone specific from bystanders and ask them to call the professional support to bring the Automated External Defibrillator. Always it is better to instruct them to call the professional support.

After that, the rescuer has to initiate cardiopulmonary resuscitation (CPR). The CPR involves 30 chest compressions of adequate depth (at least 5cm but no more than 6 cm) with a rate of 100-120 compressions per min-1 followed by artificial ventilation by exhaling air into the subject's mouth or nose – two rescue breaths. [14] Rescue breaths may be performed by using even CPR mask or CPR barrier in order to provide protection from transmission of serious diseases. This process is called artificial respiration and it has to be performed twice. After that, the rescuer repeats those two procedures until someone bring the AED that is illustrated in Figure 10.



Figure 9 - Automated External Defibrillator (AED), open, charged and ready for use [6]

After the AED is on the spot, it is necessary to follow the written or hearable instructions from the device. As the AED is a very sophisticated apparatus, it is very easy to follow the recommended steps, but resuscitation has to be performed by more than one person. A bystander should take over CPR while the rescuer will prepare the AED for the first use. The first use involves ensuring whether the adhesive pads are attached to a cable that has to be plugged into the AED. The first step is based on placement the adhesive pads to the victim's chest according to Figure 11. It is crucial not to interrupt the CPR until the AED signalise it. After signalization the AED begins to monitor the victim's heart activity. Nobody can touch the victim or the AED.



*Figure 10 - View of defibrillator electrode position and placement [21]*

In case the AED advises a shock, both participants have to ensure that nothing can disturb the shock. In other words, nobody is touching the victim or standing in a wet environment. [4] If everything is all right, rescuers are allowed to press the shock button on the AED. Immediately after the shock, rescuers have to perform CPR and follow the AED instructions. After two minutes rescuers will be commanded to stop CPR and the AED will analyse the victim again. It is necessary to follow the listed steps until the AED say “no shock advised”, or wait upon the arrival of the ambulance crew.

If the AED say “no shock advised” than it is necessary to check the pulse and breathing of the victim and wait upon the arrival of the ambulance crew.

## 10 PROFESSIONAL COMPETENCE IN ELECTRICAL ENGINEERING

The goal of the writer was to introduce the topic of electrical safety to the thesis. The electrical safety and professional competence in electrical engineering are very important to avoid the risk of injury caused by the electric shock. Due to that fact is this topic included in the bachelor's thesis.

The topic Professional competence in electrical engineering is based on the ordinance 50/1978 Coll. of the Czech law [16]. This ordinance determines levels of competency for workers who works on electrical devices. The ordinance also comprises activities such as designing of electrical devices and establishes conditions for obtaining a certification of given competency level with related duties.

The ordinance considers electrical devices as devices that may endanger the life, health, and property by electrocution. Electrical devices have to be designed with a purpose to protect against effects of atmospheric and static electricity.

The qualification levels are divided into nine groups according to various requirements.

The lowest qualification level is marked by the § 3 and it holds for ordinary workers. The term ordinary means that workers are familiar with rules about the operation and possible threats from electrical devices.

The second qualification level is marked by the § 4 and it holds for workers that are instructed. Obtaining of this qualification is the only possibility for persons, who do not have professional education in the field of electronics, or an exemption from the Czech Technical inspection. Workers are instructed in a range of their job about possible danger from electrical appliances and also about First Aid. A worker that obtains the fourth qualification level is allowed to control electric devices along with working on parts of appliances, which are not supplied and simultaneously are not 20cm from active elements under voltage. The worker is allowed to work under supervision on off devices that normally operate at high or extra high voltage. The worker that obtains fourth qualification level is not authorised to work under voltage.

The condition for obtaining of qualification level from the range 5 to 11 is a completion of professional education in the field of electronics.

The qualification level of § 5 stands for workers who are qualified. Qualified workers are those who have completed professional education in the field of electronics and simultaneously passed the test on regulation. Workers have to be tested and trained at least once in three years. The level number five allows to control electric devices independently, to work on parts of electric devices under voltage, to work in the areas of special danger under supervision, to work independently on devices of high voltage and extra high voltage. Workers are authorised to work under supervision on high and extra high voltage appliance that is under voltage.

The qualification level of § 6 holds for the independent activity of qualified workers with higher skills. For obtaining the qualification level number six, workers have to fulfil requirements that are the same as for the § 5. At least one year of experience is required. Workers are allowed to perform all operations and work on electrical appliances except prohibited works. It is prohibited to work on low voltage appliance in parallel with extra low voltage, on intersections, in public areas with high and extra high voltage, in damp and wet areas, on low, high and extra high voltage appliances, in tight wet spaces with increased and extreme corrosion, during a storm, poor visibility, darkness and wind. The limit of relative humidity that is permitted by the CSN cannot be exceeded. It is also prohibited to work, in case it is not possible to be in compliance with provisions of the relevant safety regulations.

The higher qualification level is marked by the § 7. The person who obtains this level will be able to manage activities. The requirements for this qualification level are similar to the § 5 and 6. At least one to three years' experience is required – according to the type of electrical appliance and education. Workers have to be tested and trained at least once in three years.

The person who obtains this qualification level § 8 will be able to manage activities as a contractor. The requirement for this qualification level is a professional education in the field of electronics with experience from two to six years, dependent on the type of education.

The next qualification level is marked by the § 9. The person who obtains this qualification level will be able to perform a revision of electrical appliances. Professional education in the field of electronics with experience from two to nine years is required. Workers have to be tested and trained at least once in five years.

The penultimate qualification level is marked by the § 10. The person who obtains this qualification level will be able to design electrical appliances independently, or to control the designing procedures. For obtaining it is necessary to be educated in the field of electronics with experiences. A specific regulation describes experiences and education (Act no. 360/1992 Coll.). For obtaining of this qualification level is also necessary to pass a test that is separated into two

parts. The first part is the test on knowledge of regulations to ensure work safety and technical equipment. The second part is the test on regulations associated with designing of electrical appliances.

The last qualification level is marked by the § 11. It is used as the qualification in special cases. Obtaining of this qualification level is possible for physics or electrical engineering graduates who work as assistants in school laboratories, scientific, research and development workers who are carrying out an experimental, scientific, research or development work, or for teachers who use electrical appliances for teaching. Their knowledge has to be verified at least once in three years.

## 11 DEFINITIONS

The definition of following terms which are included in this thesis is based on a description from CSN EN 61 140. [8]

**The injury caused by electric current** - physiological effect of the electric current passes through the body of a person or an animal.

**Electrical device** - device that is used for purposes such as manufacture, conversion, transmission, storage, distribution or the use of electrical energy such as machines, transformers, appliances, measuring equipment, protective equipment, management systems and appliances.

**Conducting part** - conductor or conducting part that is intended be electrically active during normal operation – including a neutral conductor. Conducting part does not include PEN, PEM, and PEL conductors according to the convention.

**Dangerous conducting part** - conducting part that can under certain conditions cause electric shock.

**Non-conducting part** - conducting part of the electric device that can be touched. This part normally does not transfer electrical current. In the case of the failure of the basic insulation, the non-conducting part can become dangerous and transmit electric current.

**Foreign conducting part** - conducting element that is not a part of the electric installation. Sometimes it can obtain electrical potential (mostly it is local ground potential).

**Basic insulation** - an insulation of dangerous live parts that provides the basic protection.

**Additional insulation** - a single insulation that is applied in addition to the basic insulation in order to ensure fault protection.

**Doubled insulation** - the insulation that consists of both – the basic insulation and the additional insulation.

**Reinforced insulation** - the insulation of dangerous electrically active parts that ensure the same electric shock protection level as doubled insulation.

**Creepage distance** - the shortest distance along the surface of a solid insulating material between two conductive parts. [23]

**Non-conducting surroundings** - the measure that protects a person or an animal who touch non-live parts that become dangerously conducting. Individuals or animals are protected by the high impedance and absence of grounded live parts.

**Protective barrier** - a part that prevents a random direct contact (contact with electrically active parts), but does not protect from intentional direct contact.

**Protective partition** - a part that provides protection against direct contact from any usual direction.

**Protective impedance** - a component or assembly of parts whose impedance and construction are created to ensure limitation of steady touch current and charge to a safe level.

**Skilled person** - a person with appropriate qualification and knowledge that enables him or her to reduce electrical risks and avoid danger.

**Instructed person** - a person that is instructed by the skilled person. Instructed person can work under supervision in order to reduce electrical risks and avoid danger.

**Layperson** - an individual who is not instructed nor skilled.

## **12 CONCLUSION**

This bachelor thesis dealt with the First Aid, especially First Aid after electrocution. The thesis was divided into two major parts: The first part is the practical manual that comprises the elementary instructions of the First Aid and various methods according to the topic of the bachelor thesis. The second part is a so-called theoretical introduction to the problematic of electrical safety because for laypersons it is useful to be instructed not only about how to provide First Aid but also about the necessary information's that comprises instructions from electrical regulations and the like.

The aim of this thesis was to briefly introduce this topic to a non-professional person who works in dangerous conditions with the risk of an electric shock or to persons that are somehow interested in this topic.

The First Aid topic is very challenging for an enormous number of people around the world because an amateurish rescuer is mostly the only person who can save the life of the injured individual, which brings the rescuer into the stressful situation. Professionals are trained to stay calm in those situations with the task of providing First Aid, unlike non-professionals who can be only prepared by mandatory courses in the context of their work or by themselves.

For the author it was very difficult to determine all the essential facts which are from electrical engineering and medicine because the writer is not a student of any medical study programme and also does not have any real experience with providing the First Aid expect calling with an emergency service dispatcher. In spite of this, the thesis was written by drawing inspiration from various professional literatures, for readers who had never been familiar with these concepts previously in order to preserve the fundamental goal.

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