ELECTRICITY - HIGH VOLTAGE – EFFECTS – POINTS TO BE CONSIDERED

In today’s world, electrical energy is one of the most prominent elements of industrialization, besides, it has become an important indicator for obtaining the development of the countries. In conjunction with the rise of industrialization, need of electrical energy occurs and the generation, transmission and distribution of electricity are becoming important day by day.

Concurrently with need of energy, “occupational health and safety” is also appearing as a rising value. Work safety issue, which is growing in importance in the all branches of industry; bring alone with increase on the studies to improve measures to protect workers and businesses while establishing, managing and maintaining the systems.

Since electricity is generated, transmitted and distributed in different levels, and used in very different areas such as housing and offices, it carries with different hazards for any fields and sectors. According to TEİAŞ statistics, each year 20 occupational accidents occurs on the average with 2 people death. When viewed from the aspect of accidents, it seems there is less accidents in comparison with other sectors, nevertheless it has still big mortality rates about %10 percents on average.

ELECTRICITY – GENERAL CONSIDERATIONS

The root cause of electrical accidents is also related with it’s properties. Electricity is invisible, it has no voice or scent, too. The reason of electrical accidents may be the problems inflicted from equipments or facility, it may also be the careless behavior of casualty with violation of rules. When human body interacts with an electrical circuit, it becomes a part of circuit. In case of electrical contact, entrance and exit points occur on the human body. In the event of electrical current flows between these enterance and exit points for a while, result can be the death of the person. Electricity may cause explosions and affect the workplace equipments adversely in the short-circuit and over-current situations as well as affecting the human body.

Especially, in consequence of high voltage of electricity flowing on human body, inner and outer burns may occur, heartbeats may be broken because of exposed frequency, even heart may stop or secondary accidents may occur due to the effect of falls arising from the impact of electric shock.
High voltage doesn’t damage on human body with only flowing all the time, but also because of the arcs that could occur related with high voltage may cause burns, eyes may be damaged and if there is an explosive athmosphere, secondary injures may occur.

**The factors related with electric shock:**

Electricity has different parameters and different electric shocks values may produce different results. These parameters:

- Current level
- Contact time
- Electrical resistance
- Contact voltage
- Frequency
- One’s response competence
- The way that current flows follows on body

The current’s effect on body according to its value is shown the following table:

<table>
<thead>
<tr>
<th>Current Value</th>
<th>Effect</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 3 mA</td>
<td>Feel</td>
<td>Paresthesias. No harm.</td>
</tr>
<tr>
<td>3 – 10 mA</td>
<td>Electrification</td>
<td>Reflexes</td>
</tr>
<tr>
<td>~10 mA</td>
<td>Spasms</td>
<td>Spontaneous muscular contraction, opistotonus</td>
</tr>
<tr>
<td>~25 mA</td>
<td>Respiratory standstill</td>
<td>The situation that may occur after accident as a result of the current passes in lobe of respiratory</td>
</tr>
<tr>
<td>Current</td>
<td>Condition</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>25 – 30 mA</td>
<td>Asphyxiation</td>
<td>The situation that may occur as a result of the current passes the rib cage area.</td>
</tr>
<tr>
<td>60 – 75 mA~5 – 10 A</td>
<td>Heart fibrillation</td>
<td>The situation that current passes on heart.</td>
</tr>
<tr>
<td>+10 A (Yüksek Gerilim)</td>
<td>Dynamic palsy</td>
<td>If current passes from the heart, it may cause fibrillation, also may act to as defibrillator. Death can be occur in a minute.</td>
</tr>
</tbody>
</table>

In addition to electric parameters, one’s own properties during shock also effect the extent of the shock. While body resistance is important parameter, other parameters that effect body resistance areas follows:

- skin tissue conditions
- contact pressure
- contact time
- current value
- current voltage
- contact surface
- current frequency

The value of body impedance also may change depending on whether the environment is dry, wet or salty. The graphic on the right shows the change of body resistance in the event of current follows the way from the one hand to another on the high contact.
surface. (IEC/TS 60479-1 (former IEC 479-1), fig.4)

1: Dry conditions
2: Wet conditions
3: Wet and Salty conditions

Change in body resistance related to the parameter, contact surface, is shown on the left (in dry conditions):

(IEC/TS 60479-1 (former IEC 479-1), fig.5)

1: Contact surface: 8.200 mm$^2$
2: Contact surface: 1.250 mm$^2$
3: Contact surface: 100 mm$^2$
4: Contact surface: 10 mm$^2$
5: Contact surface: 1 mm$^2$

STUDIES RELATED WITH HIGH VOLTAGE TRANSMISSION

Electricity pylons: Pylons is used to hold on the air undervoltage cables and above the insulators and certain distance. The point to take into consideration on the aspect of security is grounding of pylons. All pylons of production line are grounded absolutely as independent of each other. Pylon grounding is made in area with 0-30 m half diameter from the pylon corner and also made in the position and direction that provide lowest ground resistance.
Ground current that occurs in overhead line because of the electrical perforation of insulator or voltage spike to pylon from insulator resistance, flows to ground from base of the pylon or grounding electrode. This current spreads to the all directions including to the depth of homogenous earth, around the grounding electrode.

In case of a person walks to the grounded area, it is possible that a current goes by on a human body because of existing voltage on the earth. In this case, composed foot voltage depends to ground current, specifical resistivity of ground and foot width. In order to avoid these types of effects of it, grounding calculations must be well-made and implied.

**Transformer Centers:** Transformer centers can be in 3 different types; pylon type, open ground type and building type. During the works, security precautions must be taken according to the types of centers.

During the work in the pylon type centers, voltage must be cut initially. In this type of centers, safety harnesses must be used necessarily since working at height required. Moreover, protective glove and helmet must be used against to electrical risks in case of contacting to any voltage situation.

As for open ground type transformer centers, since they was built in a wide area, primarily it is necessary to knit fences that include whole region and high walls needed to be built if it is required. In addition, it is essential to provide required space between fieldworkers and to take necessary fire precautions. Open air stations must have a lock in order to avoid non-official persons’ entrance. There shouldn’t be any tresspassing to the area without the making the facility potential-free. If the subject is underground-cables, the area that cables located must be as much as away from chemical, mechanical and thermal effects or must be preserved against these. In order protect cable and its environment against the fire danger and prevent spreading of fire, cables shouldn't be floored over the combustible materials. In case of the situations that cause mechanical impact, the cables must be passed through in steel pipe.

Built type transformer centers are being set up in indoor buildings or enclosed spaces. They are generally located in downtown therefore they shouldn't damage the city aesthetics. Since these type of centers create enclosed spaces, they only need to have an securely closed doors. The necessary measures should be taken with caution signs such as ‘danger of death’ , ‘danger’ and ‘keep out’. Sufficient lightening should be provided inside of building, and special courtesy lambs that are supplied by the group of dry type battery redressors should be
used on lightening. Sufficient ventilation should be provided and heat increases occurring in transformers and cables should be taken into account with the external factors on ventilation design. Precautions should be taken against the fire and fire extinguisher equipments should be kept ready. Non-conducting carpet and stools should be used in order to protect employee through the necessary controls and maintaining interventions.

5 Golden Rules in the Works with High-Voltages:

As a minimum security measure in this high-voltage operations, the so-called five golden rules should always be followed, these rules are also valid for all operations related with electricity;

We can list these 5 rules as;

1) Disconnect the voltage

2) Preventing any possible resupply

3) Check there is no voltage.

4) Ground and short circuit.

5) Protection and marking the work area.

- **1) Disconnect the voltage**: All cut-off devices that supply energy to where maintaining takes place, should be opened completely and separation operation should be made safe with separators belonged to these.
• **2) Preventing any possible resupply**: Necessary measures should be taken in order to avoid interlocking or lockout of cut-off devices in the open position, employing mechanisms that impede unauthorised personnel from actuating these devices, on this purpose driving and control lock of these devices should be locked, with this intent mechanical, electrical and pneumatic ve physical system can be used. Hazard warning signs indicating that ‘‘it is forbidden to close’’ or ‘‘there is work on line’’ should be placed. These precautions can be taken confidently if authorised person keeps the locking key.

On the following image, it is seen that there is a portable cut-off device. After this device has been removed from the system, a warning sign should be placed in order to avoid resupply of it by mistake.

![Portable cut-off device](image)

Example of another locking system is as follows. The lever which is taken to the zero position should be locked to avoid resupplying.
As a physical precaution, placing insulating material between the cut-off devices is also shown as below;

- **3) Check there is no voltage:** If voltage is need to be removed in the some section of the facility, pronouncing the time of circuit openings/closings is not sufficient. Even if all cut-off devices that supply the work area had been opened, work needed to be started after using measurement devices and ensuring that there is no voltage in work the area. While obtaining if work area is under the voltage, should not be trusted some specialties such as backward movements of device cursors after cutting the circuit, flashed off lambs when their circuit has been cut or stopped sounds of transformers. When work is done, after it is absolutely approved that there is no hazard for workers, facilities can be taken under voltage again.

- **4) Ground and short circuit:** If work is need to be done in high-voltage facilities, work area should be short-circuited upon priorly grounded mechanism. If there is a stationary grounding system,, grounding operation can be done as below;
If there is no stationary grounding system, then portable grounding systems need to be used. Short circuit and grounding system can only be removed after all work is done and all workers had been informed.

- **5) Protection and mark the work area:** While the works goes on in facility, voltaged areas need to be covered with non-conducting materials. Safety signs that shows there are works going on in the working areas need to be used.
Studies related with high voltage can be required different safety precautions depending on the type of the work. However, should be obeyed necessary safety rules primarily. Some of these rules can be listed as below;

- Work should not be started without taking all kind of safety measures.
- People should not enter the duty or working areas without permission.
- Location of warning signs should not been changed without the knowledge of authorised supervisor.
- Should be obeyed warning and hazard signs on the working area.
- All works should be done in line with existing instructions.
- Working clothes shouldn’t be baggy or ragged to avoid contact with machine’s functioning parts.
- If protective installations needs to be removed, it should be removed after gaining permission from responsible of maintaining works.
- In the work area, maintaining works that needs to be done without stopping active systems should be done with taking safety measures and under executive supervisor supervision.
- Stationary work safety and first aid materials should be kept ready for use all the time. Personal protective equipment such as non-conducting glove, shoes, helmet and safety harness also should be kept ready and used in proper places necessarily.
- Necessary safety precautions needs to be taken with line and warning signs on the areas that prevent passing overs, cooperation need to be done with relevant organisations.
  - ‘Work in process’ signs need to be located proper places especially for the works on the roads.
  - If traffic is need to cut for a while, a red flagged signalman needs to be provided.
  - Red flags need to replaced with flashing signals at nights and signs should stay in legible condition.

Studies related with high voltage required high level safety precautions since they can cause the death of person most likely with any mistake. Beside the safety precautions mentioned on
this article, another safety precautions also need be obtained and taken with taking risk analysis results that belongs different works into account

Resources:

- Elektrik Kuvvetli Akım Tesisleri Yönetmeliği, 30/11/2000, ETKB
- İş Güvenliği Yönetmeliği, 25/02/2010, TEIAŞ
- Marcos Cantalejo García, Effects of High Voltage, INSHT