

ECET 211 Electric Machines & Control

Electrical Safety in the Workplace (part 1)

Text Book: Electric Motors and Control Systems, by Frank D. Petruzella, published by McGraw Hill, 2015.

Other References

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1-2. Electrical Safety in the Workplace

- 1. An Overview of Electrical Safety
- 2. Protecting against Electrical Shock
 - Electrical Shock
 - Arc Flash Hazards
 - Personal Protective Equipment

An Overview of Electrical Safety

- The human body conducts electricity which cause injury that has severe health effect.
- When a person come in contact with electricity (electric current), **electrical hazards** can occur and cause burns, shocks and electrocution (death) – depends on the amount of the current flowing through body.
- Electrical Safety Tips, National Fire Protection Association (NFPA)
 - U.S. fire departments responded to an estimated annual average of 47,820 reported home structure fires involving **electrical failure** or **malfunction** in 2007-2011. These fires resulted in 455 civilian deaths, 1,518 civilian injuries and \$1.5 billion in direct property damage. <http://www.nfpa.org/safety-information/for-consumers/causes/electrical/electrical-safety-in-the-home/electrical-safety-tips>

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An Overview of Electrical Safety

- **OSHA** (Occupational Safety & Health Administration)
 - **Electrical Safety, Quick Card**, https://www.osha.gov/Publications/electrical_safety.html
 - **Controlling Electric Hazards**, <https://www.osha.gov/Publications/3075.html>
 - **OSHA Occupational Safety & Health Standards**
 - 1910.269 - Electric Power Generation, Transmission, and Distribution, https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9868
 - 1910 Subpart S – Electrical, <https://www.osha.gov/dte/library/electrical/electrical.pdf>
- **NFPA 70E: Standard for Electrical Safety in the Workplace**, <http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=70e>; Free access to the 2015 edition of NFPA 70E, <http://www.nfpa.org/freeaccess>

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An Overview of Electrical Safety

- **Section 12 Electrical Safety Requirements**, 2009, Bureau of Reclamation, U.S. Dept. of the Interior, <http://www.usbr.gov/ssle/safety/RSHS/sec12.pdf>
- **UL 61010-1** Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements, http://ulstandards.ul.com/standard/?id=61010-1_3

Electrical Safety in the Workplace

- Electrical Safety covered in “The Anatomy of an Electric System,” <https://www.indianamichiganpower.com/info/educational/>
- Safety, I&M, <http://c03.apogee.net/contentplayer/?coursetype=foe&utilityid=indianamichiganpower-in&id=4651>
 - Human Response
 - Outdoor Safety
 - Indoor Safety
 - Grounding
 - Lockout/Tagout

Ch. 1. Electrical Safety in the Workplace

- Part 1. Protecting against Electrical Shock
 - Electrical Shock
 - Arc Flash Hazards
 - Personal Protective Equipment
- References:
Electric shock, https://en.wikipedia.org/wiki/Electric_shock

Part 1. Protecting against Electrical Shock

- Electrical Shock
 - Human body conduct current
 - The amount of current is the main factor determining the severity of electric shocks.
 - **Ohm's Law** $I = V/R$ or Current = Voltage/Resistance can be used to estimate the current, where
 - R = Body resistance (Ohms), V - the voltage across the human body (volts),
 - I the current in amperes, milli-amperes; $1 \text{ mA} = 10^{-3} \text{ A}$
 - **Typical body resistance**
 - Dry skin : 100,000 to 600,000 Ohms
 - Wet skin: 1,000 Ohms
 - Internal body (hand to foot): 400 – 600 Ohms
 - Ear to ear: 100 Ohms

Protecting against Electrical Shock

- Body Current Calculating Examples
 - 1. If you come in contact with 120 volts power source, and your body resistance is 100,000 ohms, what is the amount of current flowing through your body.
 - $I = V/R = 120 \text{ volts}/100,000 \text{ ohms} = 0.0012 \text{ Amperes}$ or 1.2 mA
 - 2. If you were sweaty and bare foot ($R = 1000$ ohms), what is the amount of current.
 - $I = V/R = 120 \text{ volts}/1,000 = 0.12 \text{ A}$ or 120 mA

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OSHA – Controlling Electric Hazards,

<https://www.osha.gov/Publications/3075.html>

■ Effect of Electric Current in the Human Body

Current	Reaction
Below 1 milliamperere	Generally not perceptible
1 milliamperere	Faint tingle
5 milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6–25 milliamperes (women)	Painful shock, loss of muscular control*
9–30 milliamperes (men)	The freezing current or "let-go" range.* Individual cannot let go, but can be thrown away from the circuit if extensor muscles are stimulated.
50–150 milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1,000–4,300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes	Cardiac arrest, severe burns; death probable

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Revised from Figure 1-1 Relative magnitude and effect of electric current on the body

Current	Severity and Effects
900 mA	Lights a 100 watt bulb
300 mA	Severe burns – breathing stop
100 mA	Heart stops pumping
50-90 mA	Operates an electric tooth brush
30-50 mA	Breathing difficult – suffocation possible
30 mA	Severe shock
10 mA	Cannot let go
	Painful shock
5 mA	Trip setting for Ground Fault Circuit Interrupter protection
2 mA	Mild shock
1 mA	Threshold of sensation

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Revised from Figure 1-2 Typical electric current pathways that stop normal pumping of the heart

- Path 1. Head ↔ Heart ↔ Foot
- Path 2. Hand ↔ Heart ↔ Opposite foot
- Path 3. Hand ↔ Heart ↔ Hand

Most common electric-related injury:

- Electrical burns – caused by electric current flowing through the tissues or bones
- Arc burns – a result of an extremely high temperature caused by an electric arc (as high as 35,000 °F)
- Thermal contact burns – skin comes in contact with the hot spot of overheated component

Electric shock: First aid, Mayo Clinic,
<http://www.mayoclinic.org/first-aid/first-aid-electrical-shock/basics/art-20056695>

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Typical Safety Signs and Symbols

- Samples of Electrical Hazard Labels (Source):
<http://www.safetysign.com/electrical-hazard-labels>



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Electrical Safety in the Workplace

- Protecting against Electrical Shock
 - Arc Flash Hazards
 - Arc Flash:
 - Created by (a) Mechanical breakdown, (b) Current overloads, (c) Accidental contacts
 - Creates an enormous amount of energy that can damage equipment and cause severe injury or loss of life
 - Electric workers should be familiar with safety standard: NFPA 70E – Handbook for Electrical Safety in the Workplace
- Watch/view/learn: Salisbury by Honeywell – Arc Flash Safety, 28:32 minutes video, <https://www.youtube.com/watch?v=QZ69r-x-xSM>

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Electrical Safety in the Workplace

- Protecting against Electrical Shock
 - Personal Protective Equipment
 - Arc Flash Protecting Clothing (apparel),
<http://www.salisburybyhoneywell.com/en-US/industrial/afclothing/Pages/default.aspx>
 - Rubber Insulating Gloves,
http://www.salisburybyhoneywell.com/en-US/utility/hand_arm/gloves/Pages/default.aspx
 - Hot sticks
 - Shorting probes
 - Free shields



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Summary & Conclusion

Questions?

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