INTRO

Grounding Low Voltage Power Systems

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Note: Some graphics are used with permission by the International Association of Electrical Inspectors (IAEI) and are from their course based on the Soares grounding book.

Any statements or concepts that were extracted from specific documents are noted with a numeral in { } and those references can be found on the last slide of this presentation.

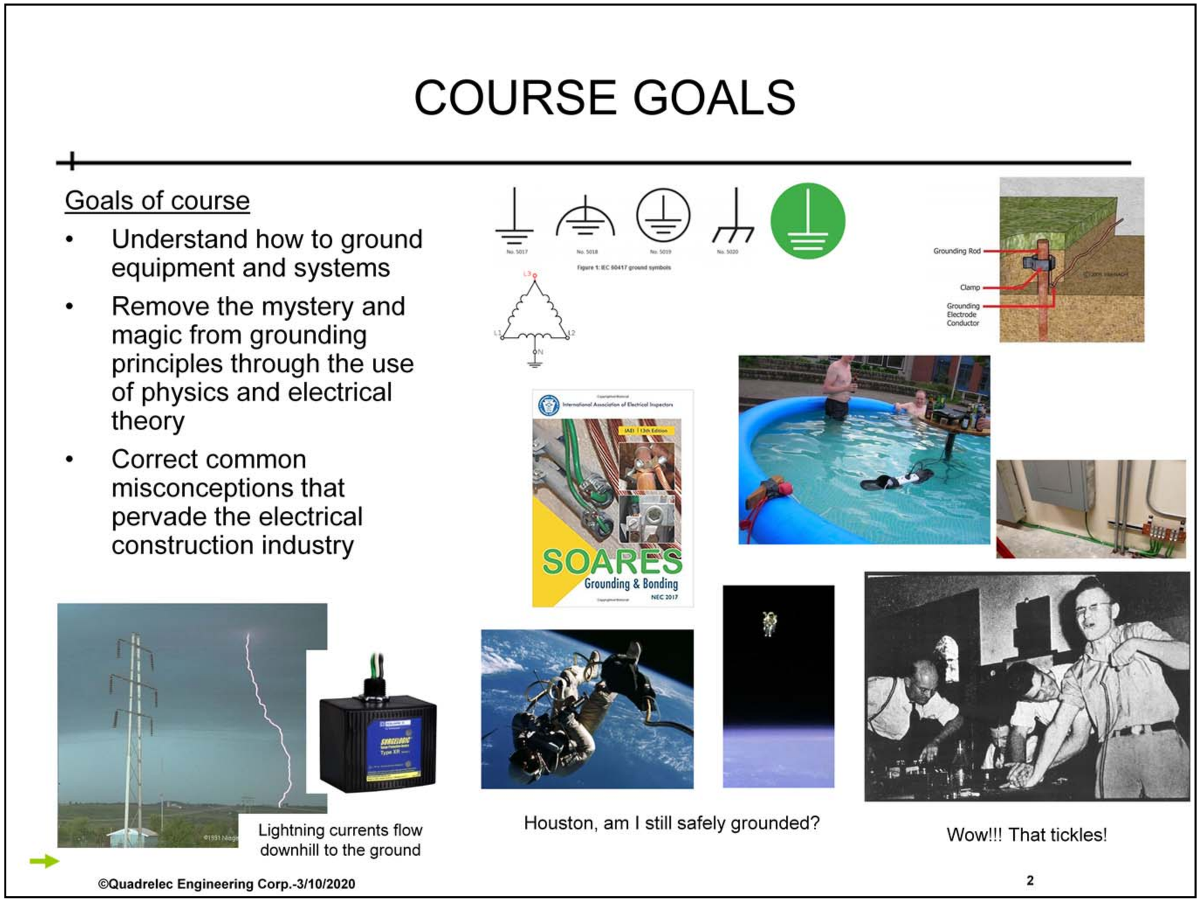
Despite all of the grounding required by the NEC and other standards, there are conditions within our daily life that prove hazardous to us humans and animals. Even with proper design low voltages < 40V can exist normally in some power systems.

To see some of what can happen when objects and equipment are <u>not</u> properly grounded check out this video.

https://www.today.com/news/stray-voltage-hidden-danger-can-strike-everyday-objects-1D80279142

or

https://www.youtube.com/watch?v=oahQRSRx_38



The instructor of this course has found over decades of electrical design, teaching, and consulting that most electricians and engineers may over time learn **how** to ground systems and equipment to meet basic code requirements such as the NEC, NESC, and lighting protection codes. It is apparent however, that what they do not understand is how the criteria was developed and **why** they are doing things the way they are. This problem is exacerbated by manufacturers of grounding equipment, wherein they convince designers and installers that they must ground things a certain way with certain equipment or the equipment will or may not be safe or properly protected.

Too many times codes and standards and even the Soares book we will refer to at times in this course contains discussions, procedures, and principles that are incorrect. Is it possible the problems noted in the previous paragraphs apply to some code panel members? Most of the errors promulgated seem to ignore electrical theory and the laws of physics. The instructor will attempt to right some of these wrongs and provide a basis to those attending as to how to determine how to ground and bond systems and equipment even when they encounter situations that may not exactly fit the code literature. The basis from this course comes from decades of experience of the instructor, Life IEEE member, electronics technician, and dealing with current flows through earth as a professional corrosion engineer. There is no better way to understand physical and electrical phenomenon by observation of instances where one's concept of what "**should**" be happening does not match what "**is**" happening. It is through those observations and input from IEEE experts that the instructor has been able to reconcile what is happening with the theory.

This course is intended to share that information.

COURSE OVERVIEW

This course module is focused on power systems 1000 volts or less

- Covers fundamentals related to the topics of grounding systems used to protect buildings, the public, and other personnel from reasonable harm while operating with or around electrical power systems
- Designed for both electricians, electrical technicians, and designers of electrical systems
- Soares "Grounding and Bonding – 2017" will be used as a reference and structural basis for this module and some inconsistencies in theory or facts will be analyzed and discussed.
- Some definitions in this course may vary somewhat from those used within the NEC

What this module does not cover

- This is not an in depth course on the National Electric Code (NEC) or National Electric Safety Code (NESC) covering all of the nuances and numerous cross-references to each and every article of those codes
- This is not a discussion of interpretations of grounding codes
- This is not a course on electrical theory or uses circuit modelling for analysis that requires a college degree. However, basic concepts such as Ohm's Law and ability to analyze basic circuits is required.
- Other course modules cover the more advanced theory and grounding system analysis, systems over 1,000-V, and lightning protection.

Hopefully this course will help you understand some of the theory behind decisions that have been made by NEC panels and that could be made in the future. Having such knowledge may aid you in case you are ever a member of a local code panel, enforcement authority, or contractor when unique situations occur where a reasonable interpretation of the NEC is required.

It is recommended that you ignore Chapters 20 and 21 of Soares book on grounding. These sections covering high-voltage and lightning protection systems are very incomplete and have many misleading and technical errors within the discussions. These topics will be covered in other course modules.

SOME COMMON GROUNDING MISCONCEPTIONS

- Current takes the path of least resistance
- Proper grounding for safety and system performance requires a connection to earth using some type of grounding electrode
- A 25-ohm or lower resistance for a ground electrode makes it safe from shock hazards
- A 1-ohm ground resistance makes equipment safer than a 25-ohm ground rod
- Sharp bends in grounding or other conductors increases the impedance of the conductor
- An ungrounded power system is safer and has a higher degree of reliability than a grounded power system
- NEC tables for sizing equipment grounding conductors are safe to use in all situations and will divert all of the ground fault current back to the source thus removing all hazardous electrical shock voltages
- Circulating currents on grounding conductors can be eliminated with proper design

The comments in this slide are some of the misinformation presented in various segments of the electrical industry. This list is not comprehensive. Attendees will no doubt expand this list as we go through this course. Some misconceptions are spread by manufacturers of grounding equipment, some are extrapolated from the NEC and NESC codes, some of them from poorly worded statements in documents including the Soare's book on grounding. All of these misconceptions come from a lack of understanding by engineers and technicians alike who seem to have forgotten or fail to use basic physics formulas and theorems common to basic circuit analysis. We will cover these in varying degrees of details in the modules of this course series. There are a number of other misconceptions related to high voltage and lightning protection systems that are covered in other modules of this course.

SOME COMMON GROUNDING MISCONCEPTIONS (Cont'd)

- Isolating grounding systems for communications, IT, power, and lightning protection from each other is best
- In order to be safely grounded, "separately derived systems" must employ an NEC acceptable earth grounding electrode
- A large copper grounding conductor such as a 500-kcmil will have a lower impedance than a steel I-beam
- Following the NEC will ensure a system design that is always safe for humans
- Using larger or specially constructed conductors to connect surge protective devices (SPD, TVSS) will allow them to perform better
- Concrete encased (Ufer type) grounding electrodes are the best grounding electrode to use
- Specially designed and manufactured grounding electrodes such as those with electrolytes or special backfill will out perform standard driven rods

There are many more that could be listed here and will be covered in this course

COURSE SUMMARY

What have we learned?

- Nothing?
- Something?
- I am more confused than when I came to the course!

What do we ground?

- Conductive parts of power system equipment that could have a voltage on them
- Power systems

Why do we ground systems?

- Reduce the stress on insulation systems during normal and abnormal operations
- Reduce and isolate the higher system voltages from the lower system voltages

Why do we ground to earth?

- Sooner or later our equipment and ourselves will be in contact with the earth so we need to make a connection to earth to reduce voltage differences

COURSE SUMMARY

What else have we learned?

- Many misconceptions exist within the industry as to how systems and equipment must be grounded and what equipment it takes to accomplish grounding
- The NEC grounding requirements:
  – Are minimum standards and may not ensure safety in many situations
  – Are combinations of both electrical theory, empirical data, and industry failures and fatalities
- Safe grounding practices to eliminate shock do not have to include earth
- Bonding is more important than connection to earth in regards to safety and equipment protection
- Shock hazards can exist even with strict compliance with industry practices
- For proper grounding system design we must understand and be able to apply at least basic electrical circuit theory.

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