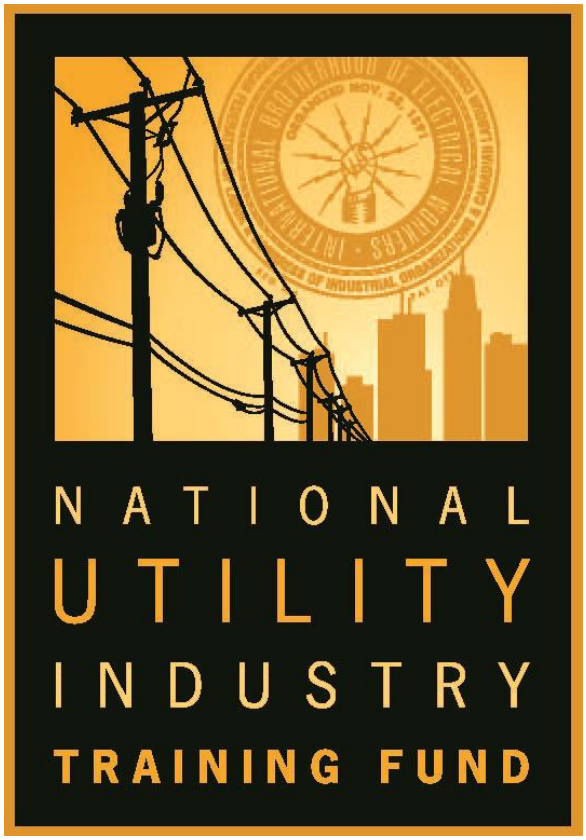
ELECTRICAL TRAINING ALLIANCE SUBSTATION APPRENTICESHIP

First Year
Lesson Learning Objectives



SUBSTATION APPRENTICESHIP
1ST YEAR – LEVEL 1
LESSON LEARNING OBJECTIVES

Lesson 1: How to Study This Course and Achieve Your Personal Goals

Introductory Information:

What you get out of this course will, to a great degree, determine your employability for years to come. This course and its contents are certainly not all it takes to make a Journeyman, but it is one of the most essential parts. You should apply yourself at all times and learn everything you can, not because it is required, but because it will make your future in this industry much better.

Certainly, you will not always see why you should study certain subjects. You will even have some poorly trained co-workers tell you that you do not need to know some of the things you study. It would be wise to compare this individual's knowledge and skill with that of the Qualified Journeymen Electrical Workers who promote the concept of quality training.

It is important that you read and review the introductory statement and the reference in each lesson. This lesson will enable you to better understand what is expected of you and how you can best succeed in studying this material.

Remember, this material is produced by your industry, for your industry, and is designed to produce **QUALIFIED** Journeymen Electrical Workers.

Learning Objectives:

After completing this lesson, you will be able to:

1. Demonstrate a positive attitude toward related training throughout your apprenticeship by completing all assignments and participating in classroom activities.
2. Develop and demonstrate good study habits by being prepared for class and asking pertinent questions related to the lesson.

Lesson 2: Knowing Your Apprenticeship and Your Responsibilities

Introductory Information

Your Apprenticeship Agreement is a very important document in your file. It sets down, in a legal contract, what you will do and what the Committee will do in regards to your apprenticeship. You should know the terms of your apprenticeship as set forth in your Apprenticeship Agreement and the Local Standards.

Learning Objectives

After completing this lesson, you will be able to:

1. Demonstrate an understanding of the terms and conditions of your Apprenticeship Agreement through classroom discussion.
2. Answer test questions pertaining to your Apprenticeship Agreement.
3. Display a positive attitude or appreciation for the investment this industry is making in your apprenticeship.

Lesson 3: The Attributes of an IBEW/NECA Apprenticeship

Introductory Information

This lesson is designed to more properly introduce you to our apprenticeship system. We believe you should know what our objectives are and what we look for when selecting, training, and employing apprentices.

Read and study the reference several times and ask questions so you thoroughly understand the local AJATC policies, rules, and penalties.

Learning Objectives

After completing this lesson, you will be able to:

1. List the qualities which identify a competent, qualified Journeyman electrical worker.
2. List the quality characteristics the JATC seeks in an applicant for apprenticeship.
3. State the primary purpose for which apprenticeship exists.

Lesson 4: Your Job and the Future it Holds for You

Introductory Information

You are a part of a vital, growing, and expanding industry. During your career, work may vary from installing an overhead feeder drop to a residence to working on large transmission towers. Qualified Electrical Workers may work for a small contractor or for a huge international electrical contracting firm. You may view yourself as a first-rate Qualified Electrical Worker, or you may decide to take the broad view and acquaint yourself with the vast implications of manpower, taxes, profits, organizations, production, safety, legislation, and hundreds of other factors affecting this industry. Our locals and our employers need informed leadership. What you get out of this industry and what you contribute to it is up to you, but as you later look back at your career, one fact is indisputable – opportunity was, and is there.

Remember also that what our Industry represents tomorrow is determined by our (yours and my) efforts today. To be successful in building and maintaining this Industry, we must all be knowledgeable of the trade, highly skilled in the mechanics of the trade and demonstrate a positive attitude toward our Union and our Contractors. To do this, we must understand the problems encountered by our Contractors.

Learning Objectives

After completing this lesson, you will be able to:

1. Explain why your future is linked directly with the contractor.
2. List the five costs of doing business.
3. Explain why management is vitally interested in training.
4. List four qualities an IBEW electrician must have.

Lesson 5: Sexual Harrassment

Introductory Information

Webster tells us that to harass is to disturb persistently, to torment, pester or persecute; to trouble by repeated attacks. Add to this, a sexual oriented motive and you have now created Sexual Harassment; something which is quite distasteful AND against the law.

On today's job sites, there simply is no room for sexual harassment. It is a serious issue—very serious if you happen to be a victim of it—and quite simply, it should not be tolerated, for whatever reason. Recent legislative and judicial action has been taken to ensure that all men and women have the right to work in an environment which is free of such discourteous and repugnant activity. Surely, this is a freedom that we all deserve and one which we must respect.

This lesson will give you an opportunity to explore the different types of situations and circumstances which can develop into a harassing situation. It is incumbent upon each and every one of us to acquire a refrain from participating in such conduct and, just as important, we will be able to readily identify harassing situations and be prepared to immediately take whatever corrective action is necessary.

Needless to say, this is not a matter which should be taken lightly—it is profoundly important and carries extraordinary ramifications with it. Individuals, contractors, associations, committees and local unions can all be adversely affected by sexual harassment in the workplace; if they chose to simply ignore it. Thankfully, our industry has chosen to do just the opposite; we recognize that harassing activity is wrong and the IBEW and NECA have both taken numerous actions directed at guaranteeing basic human rights for one and all.

As responsible human beings, sincerely concerned about the well-being of each other and the IBEW- NECA family, let us do everything we possibly can to protect ourselves from the social menace of Sexual Harassment.

Learning Objectives

After completing this lesson, you will be able to:

1. Define sexual harassment in the workplace.
2. List factors which are considered by the courts in sexual harassment cases.
3. Identify sexual harassment activity.
4. Explain the possible repercussions of participating in harassing activity.
5. React appropriately to a situation involving sexual harassment.

Lesson 6: The IBEW and its History

Introductory Information

This lesson is intended to present the story of the founding and development of unions and to illustrate their contribution to the economy and to the industry. Understanding unions and the industry is very much a part of an apprenticeship. The IBEW recognizes, as it always has, that its future depends on its Qualified Electrical Workers. The technical knowledge acquired, the skills developed, and the attitude projected by Qualified Electrical Workers will determine the future of the IBEW. A lack of technical knowledge will prevent the IBEW from being able to cope with the rapid changes in this highly technical electrical industry. A lack of skills will cause nonunion competition to be more appealing to the public—our customers. A negative attitude would destroy all of our potential. Qualified Electrical Workers must care, for the sake of their future.

Learning Objectives

After completing this lesson, you will be able to:

1. Have knowledge about the IBEW and its contributions in dignifying the lifestyle of all Electrical Workers.
2. Develop a positive attitude toward the industry and contribute to its cause.
3. Display an appreciation for what the IBEW has to offer its members.
4. Participate in a discussion concerning the history of the IBEW.

Lesson 7: NECA's Structure and Heritage

Introductory Information

The National Electrical Contractors Association, which represents the management half of our industry, has worked with the IBEW for many years in the development of electrical construction. NECA was begun by contractors who recognized that union labor could be an asset to their business. Very little of what we see today as a progressive industry would have been possible without the cooperative feelings of these early contractors, a spirit which prevails in NECA policy even today.

Learning Objectives

After completing this lesson, you will be able to:

1. Through discussion, demonstrate a basic knowledge of the NECA's history and structure.

Lesson 8: Avoiding the Hazards of Drug Abuse

Introductory Information

Using any form of illegal drugs is DUMB! That's why they call the stuff "dope." It should also be known that using alcohol, while legal for those of age, is not very intelligent either. Because the use of alcohol among adults is socially acceptable, many are lured into using it and they become victims of alcoholism or accidents induced by the mind-altering effects of alcohol.

The use of illegal drugs and alcohol in the workplace leads to unsafe working conditions, loss of productivity, and unsatisfactory work practices. NECA and the IBEW have jointly agreed to a resolution which says in part that they do *NOT* condone substance abuse in the workplace.

Careful study of this lesson will help to lead to an understanding of the problem and possible solutions to it.

Learning Objectives

After completing this lesson, you will be able to:

1. List the kinds of drugs there are.
2. Identify ways to deal with drug abuse.
3. State ways to keep your family free from alcohol and other drugs.
4. Identify specific sources available for those in need of help.

Lesson 9 This is a National Program

Introductory Information

By virtue of your selection as an apprentice in your Joint Apprenticeship and Training Committee's program, you have indeed inherited a very rich training heritage. Your industry, through its two parent organizations, the IBEW and NECA, has devoted thousands of hours, untold human energy and millions of dollars toward ensuring quality training for its apprentices and Journeymen Electrical Workers. This bilateral commitment is what brought about the founding of the NJATC in 1941.

In the past, and right on up to today, there have been thousands of supposed training programs established that were doomed to fail from the very beginning. Their failure has been predestined by the lack of two key ingredients: COMMITMENT and UNITY. Thankfully, both of these elements are at the very foundation of what the NJATC has developed into one of the most revered apprenticeship and training programs in the world.

Illustrative of the IBEW and NECA's commitment to training is the fact that in recent years nearly one hundred million dollars ($100,000,000.00) has been spent annually on the industry's training programs. This resolve to quality training is most sincere and very intense. Let us hope that your desire to be a part of this industry is equally devoted and directed toward unity, pride and productivity.

Learning Objectives

After completing this lesson, you will be able to:

1. Identify what the NJATC is.
2. Explain the history and responsibilities of the NJATC.
3. List the qualities of a superior training program.
4. Discuss the training attributes made possible through unity.

Lesson 10: Becoming Familiar with the IBEW Constitution

Introductory Information

The IBEW Constitution is a document containing the rules by which local unions operate. Local unions may have local rules, known as By-Laws, but under no circumstances can they conflict with or overrule the Constitution.

To be a good union member you must be an informed union member. Take pride in your union and most important—take part in your union's activities.

Copies of the Constitution are available at local unions.

Learning Objectives

After completing this lesson, you will be able to:

1. Demonstrate an understanding of the structure of the IBEW.
2. Identify the rules and regulations established in the IBEW Constitution.

Lesson 11: Professional Personal Conduct

Introductory Information

Conducting oneself in a professional manner is the best way to gain the respect an Electrical Worker's chosen profession deserves. Just as doctors, firemen, and police officers work hard at achieving and maintaining a professional standing, apprentice Electrical Workers should also work at becoming professionals in line work.

Learning Objectives

After completing this lesson, you will be able to:

1. List several traits that contribute to a sense of being a professional.
2. State three behavior patterns you can adopt to help perform as a professional.
3. Identify three ways that you can continue to develop as an Electrical Worker.
4. Recognize the structure and roles that make up the organization.

Lesson 12: Absenteeism

Introductory Information

Absenteeism is defined as the state of chronic absence from work. Absenteeism is usually addressed through progressively stricter disciplinary measures that can result in the termination of the individual's employment. This is generally governed by the organization's attendance policy. Several studies have shown a root cause of employee absenteeism is related to how an individual perceives him or herself at work more than any circumstances at work. There are consequences of being absent from the job. The solution is to develop a sense of professionalism, which is the main reason employees stay on the job.

Learning Objectives

After completing this lesson, you will be able to:

1. Discuss how absenteeism can be a contributing factor in on-the-job accidents.
2. Explain the true cost that absenteeism places on the company.
3. State two factors that do and do not contribute to absenteeism.

SUBSTATION APPRENTICESHIP
1ST YEAR – LEVEL 2
LESSON LEARNING OBJECTIVES

Lesson 1: Math Basics with Whole Numbers

Introductory Information:

Every day, everyone is exposed to mathematics in some form. Qualified Electrical Workers are expected to be able to use math for a variety of purposes. This lesson reviews the basic operations involved in using whole numbers, both positive numbers and negative numbers. These basic skills are the same skills employed later in more complex operations. Remember, developing a solid foundation now will allow Qualified Electrical Workers to build upon their skills later with absolute confidence!

Whole numbers, or integers, are numbers that contain no fractions or fractional parts. The whole numbers, along with the operations of addition, subtraction, multiplication, and division, form the basis of the decimal numbering system. These whole numbers are the simplest form of numbers and are the easiest to work with since they have no fractional parts. In all of these operations with integers, one of the most important keys to ensuring the correct answer is to properly align the numbers involved.

Learning Objectives:

After completing this lesson, you will be able to:

1. Add, subtract, multiply, and divide whole numbers.
2. Demonstrate skills in interpreting and solving word problems using whole numbers.
3. Understand the concept of negative numbers.
4. Understand order of operations.

Lesson 2: Fractions

Introductory Information:

It is not always possible to work calculations with whole numbers. This lesson presents ways to work with fractions. A fraction is one or more parts into which a whole unit has been divided. Fractions are regularly used in everyone's lives. It is important for Qualified Electrical Workers to be as comfortable working with fractions as working with whole numbers. Measurements and values used on the job frequently do not work out in even numbers. Therefore, it is essential to understand how to work with fractions.

This lesson covers the basic operations of addition, subtraction, multiplication, and division using fractions. Carefully study the references for this lesson, then work through the problems. If encountering any difficulties, be sure to seek the help of an instructor. His or her experience, skill, and interest in teaching this subject will be a valuable aid.

Learning Objectives:

After completing this lesson, you will be able to:

1. Demonstrate skill in working with proper fractions, improper fractions, and mixed numbers to achieve the correct form required to solve specific problems.

2. Reduce fractions to their simplest form.
3. Add, subtract, multiply, and divide numbers with fractions.
4. Demonstrate skills in solving word problems involving fractions.

Lesson 3: Decimals

Introductory Information:

In a previous lesson, basic operations with fractions were reviewed. Fractions are one way of expressing parts of whole numbers. Decimals are another, and this lesson will review addition, subtraction, multiplication, and division of decimals.

Decimals are actually fractions. In the base 10 numbering system, each digit in a decimal number represents its value times a defined power of 10, and each position is known as a place value. In working with decimals, it is important to align the individual decimal numbers correctly to solve a given problem, and the ability to determine the correct decimal point location is critical. So, remember to keep any work neat and organized, as sloppy calculations will result in errors.

The dollar system of money is the most common use of decimals that a Qualified Electrical Worker can expect to encounter. But further, in everyday work, different systems of measurement are encountered. For example, auger bits are identified by a system based on fractions of an inch, such as $^{7}/_{16}$, $^{11}/_{16}$, or $^{13}/_{16}$, while wire diameters are listed as decimal numbers, such as 0.2576 inches for the diameter of No. 2 wire. Obviously, it is necessary to be able to use and understand both systems and to convert from one system to the other.

Learning Objectives:

After completing this lesson, you will be able to:

1. Convert fractions to decimal numbers and decimal numbers to fractions.
2. Recognize common fraction and decimal equivalents.
3. Add, subtract, multiply, and divide decimal numbers.
4. Demonstrate skills in solving word problems that involve decimal numbers.

Lesson 4: Percentages

Introductory Information:

A percent is simply a measurement that compares a number to 100 and uses the symbol % for percent, which means *hundredths*. People use percentages daily for such things as calculating the sales tax on a purchase or determining the interest payment due, based on a given percentage rate. As a Qualified Electrical Worker, it is necessary to be comfortable and confident in working with percentages, which are used in a variety of ways in the industry. Electrical and safety codes use percentages to specify values, and percentage calculations are used to determine such things as voltage drop, transformer impedance, overload capabilities, wage rates, and take-home pay.

In this lesson, skills of decimal multiplication previously presented, along with skills developed in working with fractions will be used. This is another basic math skill that will serve Qualified Electrical Workers well for the rest of their lives and help them master their trade.

Learning Objectives:

After completing this lesson, you will be able to:

1. Convert percentages to or from decimals and fractions.
2. Accurately calculate percentages.
3. Demonstrate skills in using percentages to express values and to solve word problems.

Lesson 5: How to Solve Basic Algebraic Equations

Introductory Information:

The ability to solve simple equations is a necessity in the study of electricity.

The processes necessary to solve simple equations are a necessity in the study of electricity. You will need to work with many formulas in the course material as you go along.

The lesson will not attempt to teach algebra, but is intended as a review and refresher in handling simple equations. If necessary, arrange to take further schooling in this subject matter by utilizing the *electrical training ALLIANCE Building a Foundation in Mathematics* course. More mathematical skills and knowledge will be demanded as the related material becomes more complex.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Demonstrate your skill in developing algebraic formulas to solve word problems.
2. Demonstrate in class your ability to solve algebraic equations.
3. Work with arithmetic signs of operation in setting up and solving algebraic definitions.

Lesson 6: Working with Ratios and Proportion

Introductory Information:

To understand transformers, ratios of turns, volts, and currents must be understood as well. To properly select pulleys and gears for motor drives, the ratio of sizes needed to give the desired speed will need to be calculated.

Many circuits involve the division of loads in proportion to the components.

Keep in mind that a ratio is a divisionary comparison (in the form of a fraction) of two like quantities that are expressed in the same units of measurement.

Proportion is a statement which indicates that two ratios (fractions) are equal to each other. There are two types of proportional relationships, *direct* proportion and *inverse* proportion. Make sure to understand the difference and how to set up each proportion correctly. When solving proportion problems, always remember to: set up the proportion in correct order, substitute the known values, solve by using cross-multiplication.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Demonstrate your knowledge and ability for solving ratio and proportion problems.
2. Demonstrate an understanding of mathematical rules as they apply to ratio and proportion problems.
3. Recognize and solve problems involving both direct and inverse relationship.

Lesson 7: Working with Prefixes and Powers of 10

Introductory Information:

Electricity is a science, therefore the metric system and powers of 10 are both used to express electrical quantities. To work with electricity, you must not only be familiar with these methods of expressing electrical quantities, you **mus**t also be able to work with these units and make appropriate conversions.

Metric prefixes are used extensively to report measurements of electrical units. Measurements such as kilovolts, megohms or milliamperes are common in electrical terminology. Therefore, you must learn how to work with metric prefixes in order to use and understand these electrical quantities.

A knowledge of how to use powers of ten will simplify the process of solving problems involving numbers which contain a large number of zeros. Knowing how to use powers of ten will also enable you to easily estimate the results of simple calculations containing numbers with a large number of zeros.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain the value of metric prefixes.
2. Convert from one prefix to another.
3. Change from prefixed numbers to whole numbers and from whole numbers to prefixed numbers.
4. Use powers of ten to quickly perform basic mathematical functions.

Lesson 8: The Customary and Metric Systems of Measurement

Introductory Information:

The United States currently uses the customary or English system of measurement, while nearly all other countries in the world use the metric system. Qualified Electrical Workers will benefit from an introduction to the metric system, the basic units of measurement used, and the common prefixes used with the basic units. If, as a student in high school, an apprentice studied the metric system, this will serve as an in-depth review. The metric system, based on the powers of 10, is elegant in its simplicity. Further, conversions to another unit of metric measurement are much simpler and more efficient than in the customary system.

The U.S. has been slow to adopt the metric system as its standard, but efforts are being made to convert to metric measurements. The construction and electrical industries are among those leading these efforts, despite the huge impact of converting to the metric system, because the industry is measurement sensitive. Just consider the effect such changes will have in tools, materials, prints and specifications, to name a few. However, to be competitive in

world markets, the U.S. will eventually have to convert, and Qualified Electrical Workers need to be prepared. The result is a much easier system of measurement.

Remember: Think Global. Think Competitive. Think Metric!

Learning Objectives:

After completing this lesson, you will be able to:

1. Demonstrate a knowledge and understanding of comparing the customary system with the metric system.
2. Accurately make mathematical conversions from customary to metric measurements.
3. Explain the advantages of the metric system.

Lesson 9: The Circle

Introductory Information:

A circle is a closed curved line whose points are in a plane such that they are all equal in distance from a common point called the center. The characteristics of a circle include the radius, the diameter, the circumference, and the area. There is a definite relationship that exists among the characteristics of a circle, and if two of the measurements are known, the others can be calculated. It is important to understand these relationships.

One of the more interesting relationships is that between the circumference and the diameter of a circle. In all circles, regardless of the size of the circle, the ratio of the circumference to its diameter is the same number, namely, π. This symbol is a non-terminating number, meaning there is no end to it, but it has an approximate value of 3.1416. To simplify the arithmetic, use 3.14 or $3\ ^{1}/_{7}$ to work problems in this lesson. No greater accuracy should normally be required.

Learning Objectives:

After completing this lesson, you will be able to:

1. Define radius, diameter, circumference, and area of a circle.
2. Calculate each of the measurements of a circle.
3. Understand how π (pi) is used in calculations.

Lesson 10: Area and Volume

Introductory Information:

There are many situations where a Qualified Electrical Worker may be asked to calculate the area of an object or the volume of a substance. It is important to know the methods and formulas used to make such calculations. The useful formulas for both area and volume should be learned and understood, as they are very helpful on the job. Read the reference and see some of the “real world” situations where these calculations can be used. If any of the math involved proves troublesome, review previous math lessons and/or talk to an instructor.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the formulas for finding the area of a rectangle, parallelogram, and triangle.
2. State the formulas to find the volume of a rectangular prism and a cylinder.
3. Solve math problems involving area and volume.

Lesson 11: Current, Voltage, and Resistance in a Circuit

Introductory Information:

To understand and discuss any subject, words must have definite meanings. Electrical terms are no exception. In this lesson, you will be introduced to three elementary terms that are necessary before you can start discussing and understanding basic circuits.

These terms are current, voltage, and resistance. Current, voltage, and resistance are the fundamental units of an electrical circuit. These are units of electricity that you will work with on a daily basis as well as the three elements needed to make a circuit function the way it is intended to function.

In this lesson you will be introduced to current, voltage, and resistance. You will learn the function and purpose of each of these and you will learn how to safely measure current, voltage, and resistance in a circuit.

Learning Objectives:

After completing this lesson, you will be able to:

1. Define electricity.
2. Describe current flow and how current flows in a circuit.
3. Define terms associated with current, voltage, and resistance.
4. Explain how to safely measure current, voltage, and resistance.

Lesson 12: The Electrical Circuit and Ohm's Law

Introductory Information:

A previous lesson introduced three units of measurement in an electrical circuit. This lesson expands on the importance of these units and explains how they are affected under certain conditions. The usage of Ohm's Law will be introduced and how this law is used to solve for the unknown in an electrical circuit.

This lesson is one of the most important that you will ever study. You will see how Ohm's Law defines the relationship between these three basic electrical units. You will see that as long as you know any two of the three values, ***E*** (**E**lectromotive force or Voltage), ***I*** (current or **I**ntensity), or ***R*** (**R**esistance), then the third unknown one can be easily solved by a simple arithmetic process. Be sure that you understand the relationship between the three quantities and are accurate with the arithmetic involved.

A short circuit has almost no resistance and a high-current flow.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the operation of simple circuits.
2. Solve mathematical problems using Ohm's Law.

3. Explain how and why prefix multipliers are used in equations and circuit values.

Lesson 13: Power in a Circuit

Introductory Information:

In a previous lesson on Ohm's Law, the interrelationship of current, voltage, and resistance in an electrical circuit was discussed. Now to introduce the term: *power*. Any time a voltage is applied and current flows, a definite quantity of power is expended. The amount of power is just as definite and follows mathematical laws just as *E*, *I*, and *R* do.

This lesson teaches the fundamentals of power as well as how to calculate power in a simple circuit.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. When performing conversion calculations for horsepower/power, use 1 HP = 746 W. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe how electrical power is utilized or dissipated.
2. Mathematically solve circuit problems using Ohm's Law and/or Ohm's Law for power.
3. Explain the units of measurement for both mechanical and electrical power.

Lesson 14: What is Electricity?

Introductory Information:

Electricity has always existed in nature, but only with the development of a scientific explanation of what it is and where it comes from has it become possible to create the vast variety of electrical and electronic devices available today. A thorough understanding of the nature of matter is necessary to understand electrical theory. The Qualified Electrical Worker works daily with the invisible forces of the atom which are as potentially dangerous as they are useful.

In a solid material such as copper, electrical current flow is said to be electron flow. To understand current flow it is necessary to understand the behavior of electrons.

This lesson will provide the foundation necessary to understand what has to happen to be able to create electricity.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the basic structure of an atom.
2. Name the three main particles which are part of all but the simplest atom.
3. Describe the electrical characteristics of an atom.
4. Describe the relation between valence (free) electrons and electron movement (current flow).

SUBSTATION APPRENTICESHIP

1ST YEAR – LEVEL 3

LESSON LEARNING OBJECTIVES

Lesson 1: Electrical Energy Sources

Introductory Information:

Electrical energy may be produced in several ways and can be utilized by taking advantage of its different effects. When current flows through an electric range element the heat produced is useful and desirable. When current flows through an electric motor, heat produced is undesirable but its magnetic effect is useful.

Water can be turned into an electrical conductor by adding salt.

Work toward understanding the principles by which all electrical devices operate.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify and describe the different means of producing electric current.
2. Describe the makeup of a battery and explain how to determine polarity.
3. Explain how electricity can create heat and light.

Lesson 2: Electrical Switches

Introductory Information:

Up to this point in your studies you have learned about the fundamentals of how electricity works in theory. You have been introduced to a basic circuit and you have been introduced to how current flows.

This lesson will introduce you to controlling the circuit by starting and stopping the flow of current (opening and closing the circuit). As simple as this may seem, it is important that you understand the different types of switches as well as how these switches function in a circuit.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe how a switch functions in a circuit.
2. Explain the terminology used to describe switches

Lesson 3: Conductors, Conductor Resistance, and Wattage Loss

Introductory Information:

The conductors we use in electrical circuits will vary from circuit to circuit depending on many different factors. These factors will include the size of the load, the distance that current will have to travel, the size of the pipe, etc.

This lesson will introduce you to the many considerations you will encounter as an electrical worker regarding conductor sizing, the resistance of the conductors, wattage loss, voltage drop along the conductors, and efficiency. It is extremely important to fully understand the objectives of this lesson as you as an electrical worker will need to utilize these skills daily.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe how conductors are sized.
2. Understand how to determine the resistance of a conductor.
3. Explain how the material and the length of a conductor will affect the resistance, wattage loss, and voltage drop of the circuit.

Lesson 4: Introduction to Electrical Devices

Introductory Information:

To understand electrical and electronic circuits, you will need to learn many new terms. In addition to new terms, you will also need to learn about electrical and electronic symbols and how to read drawings used to represent electrical circuits.

This lesson introduces symbols for some of the individual components or devices that will be included in your study of electrical theory. Try to learn as many of these symbols as possible. Do not worry about the theory behind the operation of each of the devices at this time, as that will be discussed in the lessons in which each component is introduced.

This lesson will also introduce you to one of the more common devices in an electrical circuit, the resistor. This device will be used in many of the circuits you will be studying throughout the *DC Theory* lessons.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify which component an electrical or electronic symbol represents when you see that symbol in a drawing or schematic.
2. Draw the correct symbols for electrical or electronic components when making schematic drawings.
3. Identify different types of resistors.
4. Identify the value of a resistor by the color-coded bands.

Lesson 5: The Series Circuit

Introductory Information:

In the previous lessons you were introduced to the basics of electricity, including resistance, current, voltage, and power. You were introduced to the fundamentals of a circuit and more importantly how Ohm's Law can be used to find unknown values in a circuit. From this point forward, you will start to put the previous lessons together to solve unknown values within a circuit. You will be introduced to fundamental rules which you will need to follow when working with various circuits. There are five common sense rules that can be used for solving circuits of any type:

1. To solve for an unknown circuit value, you must know at least two of the four possible values (resistance, voltage, current, power) for the component.

2. Always consult the Ohm's Law/Watt's Law chart to determine the correct formula to use.

3. Always double check your work using Ohm's Law.

4. Always be patient when solving for circuit values.

5. Never overlook the obvious.

It is extremely important that you fully understand that all previous lessons were introduced to you as a building block and that you will need to refer back to previous lessons if you do not fully understand an electrical concept.

The most basic type of circuit is the series circuit in which there is a single path for electron flow from the negative terminal of the power source, through the circuit, and then to the positive side of the source.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain the four basic rules to find values in a series circuit.
2. Use Ohm's law to solve unknown values in a circuit.

Lesson 6: Understanding and Calculating Resistance in DC Series Circuits

Introductory Information:

One definition of an electric circuit is a combination of a power source, a load, and the connecting wires (or circuit conductors). The most basic type of circuit is the series circuit in which there is a single path for electron flow from the negative terminal of the power source, through the circuit, and then to the positive side of the source.

In a series circuit the load, connecting wires, and even the power source all contribute to the resistance of the circuit. You have already studied Ohm's Law. In this lesson you will use Ohm's Law to help study resistance in series circuits.

In future lessons you will study voltage, current, and power in series circuits. You should know already, from your study of Ohm's Law, that these electrical values are all related. In this lesson, however, you can begin to develop a basic understanding of how this relation is important in electric circuits.

In addition, in this lesson you will review how meters can be used to measure electrical resistance in a circuit.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Draw and label basic components of electric circuits.
2. Calculate the total resistance in series circuits using both the formula for series resistance and Ohm's Law.
3. Review the procedures for measuring resistance using a multimeter.

Lesson 7: How Current Reacts in DC Series Circuits

Introductory Information:

In almost all electric circuits, wires are used to connect components together. These wires provide a path between the circuit elements for the electrons which comprise the electric current. In a series circuit, there is only path for these electrons and they must all travel this same path.

An electric current is defined as the movement of electrons. If all electrons must travel the same path throughout a circuit, the circuit is called a series circuit and the current will be the same for all points in that circuit.

Since all circuit current flows through every component in the circuit, each component must be considered as a load in determining the total current. Ohm's Law defines the relationship between voltage, resistance, and current. In the last lesson, you studied how the resistance of individual components in a series circuit add together to determine total resistance.

Recall from an earlier chapter that there are primarily two devices used to limit the amount of current flow in a circuit. These devices include the fuse and the circuit breaker. When considering the size of a circuit breaker or fuse you must understand that the total current in the circuit plays a major role in the size of these devices. In this lesson you will look at how voltage and total circuit resistance play equally important roles in determining series circuit current.

A very important part of understanding Ohm's Law and currents in series circuits is your knowledge of how to measure current in a circuit. In this lesson, you will review how the current in a series circuit can be measured.

Please make note, subscripts are often used in electrical formulas to properly identify which components are being referred to.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Draw and label some new components and additional electrical circuits.
2. Calculate the effect of changing voltages and resistances on circuit current.
3. Determine how some circuits may be modified to control circuit current using Ohm's Law.
4. Measure the current in a series circuit using either an analog or a digital meter.

Lesson 8: Voltage in Series Circuits

Introductory Information:

Every electrical circuit must have a source of voltage to operate. The voltage source provides potential energy to the circuit. This energy is utilized by the circuit to accomplish work, but no work is done in the circuit unless the voltage

source is connected to the circuit in such a way that current flows through the circuit. The voltage source is sometimes referred to as the voltage potential or potential source.

In the series circuit, voltage sources are connected in series with the load or loads and any interconnecting wires that may be incorporated into the circuit. This voltage supply to the circuit may be a simple voltage source, such as a single battery, or it may be more complex, such as when several voltage sources are connected in series. For example, in some flashlights, more than one battery cell is required.

The voltage is supplied in a series circuit. It is the source that determines the energy available to that circuit. Circuit voltage is as important in determining circuit current as is the total resistance of the circuit. Ohm's law defines the relationship between these two electrical variables and the current (electrons) that flows in the circuit.

The relationship between voltage, resistance, and current in the series circuit will be reviewed. However, the emphasis will be on the voltage source found in the circuit and on the voltages developed across individual components in the circuit. For unlike current, the voltage across each component of a series circuit will vary in proportion to the resistance of that circuit component.

Learning Objectives:

After completing this lesson, you will be able to:

1. Use Ohm's Law to determine the voltage applied to a series circuit or to individual components in a series circuit.
2. Calculate the effective voltage applied to series circuits.
3. Use analog and digital multimeters to measure voltages across series circuit components.

Lesson 9: How to Calculate Power in DC Series Circuits

Introductory Information:

The amount of power delivered to a circuit is a measure of the amount of work done by that circuit. Some power is delivered to the load and performs useful work, while other power which may be delivered to the circuit is dissipated as heat and is wasted in the circuit (unless, of course, the circuit is designed to generate heat).

In this lesson on power in series circuits, we will examine how the total power delivered to a series circuit can be calculated. In addition, we will learn how to determine the power dissipation of any individual component in the series circuit.

One important consideration is how much power is lost or not actually used to perform the work for which the circuit was designed. In this lesson, we will examine circuits in which there are power losses, and we will learn to calculate those power losses.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Draw and label series electrical circuits which contain power rated devices.
2. Calculate the total power used in series circuits.
3. Calculate the power used by individual components in a series circuit.
4. Calculate the power wasted in a circuit.

Lesson 10: How Current Reacts in a DC Parallel Circuit

Introductory Information:

The previous study on series circuits taught that the current through each component of the circuit was the same, and that the sum of the voltages dropped across each of the loads in the circuit was equal to the source voltage for that series circuit.

The definition of a parallel circuit is a circuit in which there are one or more points where the current divides and follows different paths. A circuit in which there is only one current path cannot be a parallel circuit.

The total current in a parallel circuit is defined as the sum of the branch currents ($I_T = I_1 + I_2 + \ldots I_N$), just as the total voltage in a series circuit was defined as the sum of the load voltage drops. In a parallel circuit, the current in any one branch is not affected by the currents in any of the other branches. However, the total current is affected by each of the branch currents.

Power sources of equal voltages can also be connected in parallel. When this is done, each source provides an equal portion of the current that is supplied to the connected load or loads. Therefore, the circuit's total current divided by the number of power sources connected in parallel will determine the current supplied by each source ($I_S = {}^{I_T}/_{NS}$).

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe how the current flow rule for parallel circuits differs from the current flow rule for series circuits.
2. Calculate the currents in individual branches of parallel circuits.
3. Determine the total current in parallel circuits.

Lesson 11: Understanding Resistance in DC Parallel Circuits

Introductory Information:

In this lesson you will look at resistance in parallel circuits. In a previous lesson, you studied resistance in series circuits where the total circuit resistance was always greater than any of the individual resistances in the circuit.

In parallel circuits, the total circuit resistance is always less than any of the individual resistance values in the circuit. In many applications, the total or equivalent resistance of the parallel circuit is more important than the values of the individual resistors. In other applications, the reverse is true.

In this lesson you will learn the formulas which can be used to solve for resistance values in parallel circuits.

Be prepared to show your work. All calculations must be completed on paper and taken with you to class. Questions that require a keyed numerical answer must be answered in the form of a decimal, as opposed to a fraction.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify circuits containing parallel resistors.
2. Calculate the total circuit resistance of parallel circuits with two resistance values using the product-sum method.
3. Calculate the total circuit resistance of parallel circuits with two or more resistance values using the reciprocal method.

Lesson 12: How Voltage Functions in a DC Parallel Circuit

Introductory Information:

In series circuits there is only one path for current flow, meaning the current in all components of the circuit is the same.

Another type of circuit is the parallel circuit. In parallel circuits, there are alternative paths for the current to flow within the circuit. Since there are different current paths, the current through each component in the circuit is not necessarily the same. In fact, in parallel circuits, the total current in the circuit is equal to the sum of the current through all of its branches: $I_T = I + I + \ldots I_N$.

However, in parallel circuits all components are connected across the same voltage source. As a result, the voltage applied to each component in the circuit is the same: $V_T = V_1 = V_2 = \ldots V_N$. Subsequently, Ohm's Law is applied differently in solving problems involving parallel circuits.

The first step is to gain an understanding of how voltage functions in parallel circuits, including more characteristics of electrical circuits.

Learning Objectives:

After completing this lesson, you will be able to:

1. Solve problems involving voltage in parallel circuits using Ohm's Law.
2. Identify and describe differences between voltage sources in series and parallel circuits.
3. Describe how parallel circuit voltage rules differ from series circuit voltage rules.

Lesson 13: How to Calculate Power in a DC Parallel Circuit

Introductory Information:

Power calculations for parallel circuits are similar to power calculations for series circuits, in that the total power consumed in a parallel circuit is the sum of the power consumed in the individual components of that circuit; just as the total power in a series circuit is equal to the sum of the power in the individual components of that circuit. Power calculations for these two types of circuits are also similar because in both circuits, the total power is the product of the source voltage and the total circuit current.

A deeper understanding of the relationships between the variables in series and parallel circuits will help when dealing with combination circuits, or circuits that contain both series and parallel components.

Learning Objectives:

After completing this lesson, you will be able to:

1. Show the power required by each individual component in a parallel circuit.
2. Calculate the total power consumed in a parallel circuit using the power consumed by individual components.
3. Calculate the total power consumed in parallel circuits from the source voltage and total current delivered to that circuit.
4. Determine power ratings of components in parallel circuits.

Lesson 14: The Principles of Magnetism

Introductory Information:

Without magnetism, a major source of electrical energy would be lost. Most of the magnetic fields used in industry are created by electrical current. Whenever electrons flow, magnetic flux is produced. Whenever magnetic flux lines are cut by a conductor, a voltage is induced in that conductor. Whenever a voltage is present and a circuit is complete, electrons (current) will flow. As an electrical apprentice, nearly everything done involves (directly or indirectly) one or more of the conditions described above. It is essential to understand the principles that are involved and to focus on the relationships of electron flow and magnetic flux.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain the theories of magnetism.
2. Explain how electromagnetism performs useful and meaningful work.
3. Demonstrate an understanding of magnetic materials through classroom discussion.

SUBSTATION APPRENTICESHIP

1ST YEAR – LEVEL 4

LESSON LEARNING OBJECTIVES

Lesson 1: Introduction to OSHA

Introductory Information:

The Occupational Safety and Health Administration (OSHA) was formed in 1970 to "provide for the general welfare, and to assure so far as possible every working man and woman in the Nation safe and healthful working conditions, and to preserve our human resources." OSHA places a great responsibility on your employer to assure a workplace that is free from hazards. OSHA ensures workplace safety. The purposes of this lesson are to introduce OSHA, to introduce the regulations to be followed and discuss where to find documentation of such regulations, and to provide a basic knowledge of how OSHA operates. Understanding these critical issues ultimately leads to safer work places and better work practices.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the reasons for the formation of and need for OSHA.
2. State the need for OSHA.
3. Describe the responsibilities of the employer under OSHA.
4. Describe the rights and responsibilities of the employee under OSHA.
5. State the basic regulations in 1910.269, 1926 subpart V, 1910.268, the NESC and how they relate to each other.

Lesson 2: Responsibility for Safety

Introductory Information:

Personal safety for every Qualified Electrical Worker is in his or her hands every day on the job. By now, apprentices should have become familiar with OSHA – the Occupational Safety & Health Administration, which was established in 1970. The sole purpose of this agency is to keep American workers safe while on the job. Every employer has policies and procedures in place to comply with OSHA, which Qualified Electrical Workers are expected to comply with as part of their job. Yet, complying with regulations should not be the main motivation for following the rules. The real motive should be to keep oneself and one's fellow workers safe. At the end of the day, it will not be the safety director or the job supervisor who will be hurt and missing work – it will be you.

Learning Objectives:

After completing this lesson, you will be able to:

1. State three responsibilities of the employee to help control accidents.
2. List three hazards that must be addressed during a job site briefing.
3. State two requirements of a job site briefing.

Lesson 3: Personal Protective Equipment

Introductory Information:

When job site hazardous conditions cannot be removed, it becomes necessary to use personal protective equipment (PPE) to protect workers. PPE is any equipment that can be used to create a barrier between the worker and the job site hazard. If, for example, the potential for falling objects is present on a job, hard hats (helmets) are to be worn to protect the worker.

The purpose of this lesson will be to review some of the common types of PPE that are available and understand when they are required to be used by the Qualified Electrical Worker. In addition, everyone must understand the limitations of PPE and the importance of ensuring their PPE is in good operating condition prior to use.

Learning Objectives:

After completing this lesson, you will be able to:

1. Select the proper type of PPE for the conditions that are present on the job.
2. Describe when PPE is required by the OSHA standards.
3. Identify the limitations of PPE as they relate to their job site usage.

Lesson 4: Electrical Awareness

Introductory Information:

For Electrical Workers, few other jobsite hazards are of more concern than the risk of electrical shock. Being aware of the hazards involved in the electrical industry is the first step in being able to safeguard oneself and one's coworkers.

Grounding will be introduced briefly. More detailed and comprehensive information on this subject will be presented later in the apprenticeship. This basic introduction is important and will introduce a number of the techniques used for grounding. Voltage gradients and truck grounding are essential for personnel and jobsite safety and will also be introduced. Qualified Electrical Workers must recognize and understand similarities and differences between personal protective grounding and grounding a circuit.

This lesson is general in nature and an apprentice should take full advantage of his or her Journeyman and Foreman to help recognize the hazards he or she will be working around.

Learning Objectives:

After completing this lesson, you will be able to:

1. Determine what factors will affect the severity of an electrical shock including various shock current intensities and their effects.
2. State techniques and devices for protecting personnel against electrical accidents.
3. State the definition of voltage gradients and ground-faults.

Lesson 5: Energized and Non-Energized Parts

Introductory Information:

To comply with industry safety regulations at the federal, state, and local levels, as well as an employer's safety requirements, it is imperative to be able to recognize electrical hardware. Knowing the function of different types of hardware used throughout the industry and what parts could normally be expected to be energized is important. Only "qualified" employees may work on or near energized electrical apparatus. Industry safety standards establish the minimum distances that must be observed when approaching energized equipment. This lesson will help to develop the skills necessary to recognize and distinguish energized from non-energized electrical apparatus. Future lessons will provide a more in-depth explanation of various types of hardware and their uses.

Learning Objectives:

After completing this lesson, you will be able to:

1. Distinguish energized line parts from other parts of electrical equipment.
2. Determine the nominal voltage of exposed, energized parts.
3. Determine the distance that must be maintained when a qualified employee approaches exposed energized parts.

Lesson 6: Substation Construction – Safety and First Aid

Introductory Information:

Substation accidents can be prevented if appropriate safety procedures are followed. Because substation hazards may not be familiar to all Qualified Electrical Workers, on-site job briefings become a critical component for all jobs. An example of an item that should be covered in a daily job briefing would be how to perform a rescue off of the top of a transformer, or in the lattice work of a substation.

Along with the reference materials for this lesson, the following studies should be studied to obtain a firm understanding of the safety and first aid requirements when working in substation yards: OSHA 1910.269(b), 1910.151, 1926.950€, 1926.50, NESC 410.B, and NESC 420.A.

Learning Objectives:

After completing this lesson, you will be able to:

1. State two requirements when administering first aid.
2. List two distances, in feet, workers may approach an energized line or piece of equipment.
3. Discuss two requirements of safety equipment.

Lesson 7: Live-Line Tools - Introduction, Identification, and Care

Introductory Information:

Qualified Electrical Workers and especially live-line workers are members of the trade who, with proper training, will use a "stick" to work voltages most Electrical Workers would consider too dangerous to approach.

At some point in every Qualified Electrical Worker's career, someone will hand him or her a "stick" and tell them to reach out and work high voltages with it. The Qualified Electrical Worker's safety at that point may depend on something as simple as housekeeping; how well taken care of is the stick he or she is about to use? It is vital to be familiar with the identification and care of live-line tools. When working distribution and transmission voltages, knowing what "sticks" will support the weights and voltages involved is critical.

OSHA 1910.269(j), Live-line tools, does not differentiate between live-line tools used for distribution work or for transmission maintenance; it simply concerns live-line tools. Paragraph (j)(2) of this OSHA section states, "Each live-line tool shall be wiped clean and visually inspected for defects before use each day." OSHA 1910.269(j)(2)(ii) also calls for live-line tools used for primary employees' protection to be removed from service every two years for examination, cleaning, repair, and testing. OSHA requires that IEEE (Institute of Electrical and Electronics Engineers) Standard 978-1984 be followed for electrical testing of all live-line tools.

In distribution live-line work, most employers require Qualified Electrical Workers to wear rubber gloves, but in transmission live-line work, the stick is the primary protection. Being able to properly identify, use, and care for live-line sticks may be the deciding factors in whether a Qualified Electrical Worker has a safe day or not.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify equipment used in live-line maintenance.
2. State safety requirements of equipment involved with live-line work.
3. State procedures for repairing live-line tools.

Lesson 8: Fall Protection

Introductory Information:

The most common cause of worker fatalities in the construction industry is falling. OSHA Subpart M is a fall protection standard designed to reduce worker fatalities from falls on construction sites. The purpose of this lesson is to review the requirements of Subpart M as they relate to worker protection from falls. By studying the requirements of this OSHA standard, workers will understand when fall protection is required and what options are available for their protection.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify job place working conditions that require fall protection.
2. Discuss the fall protection options that are available once the need for fall protection has been established.
3. State individual elements of each of the fall protection options.
4. Define the fall protection terms used throughout the fall protection standard.

Lesson 9: Baskets, Aerial Lifts, and Platforms

Introductory Information:

Aerial equipment is commonly used in the electrical construction industry, not only for setting poles, but often also to handle other heavy materials used in day-to-day work. Man-lifts increase production, reduce stress, and increase safety for the worker.

The safe operation of aerial equipment is one key in preventing injury to personnel and equipment damage. Qualified Electrical Workers have been injured or killed when they have failed to recognize hazards or follow safety rules and manufacturer's guidelines.

Qualified Electrical Workers should have a solid foundation in working on or around aerial equipment. The next step is to apply what is learned in this lesson "on the job" by knowing where to find the operator's manual and becoming familiar with equipment to be operated or worked around.

Learning Objectives:

After completing this lesson, you will be able to:

1. Recognize associated hazards with the operation of aerial equipment.
2. Understand the safe operation of aerial equipment.
3. Recognize safety labels and inspection points found on aerial equipment.
4. Locate and understand operator's manuals.

Lesson 10: Substation Structure and Rescue

Introductory Information:

Structure rescue is a skill every worker must be proficient in not only for the safety of fellow workers but also for his or her own safety.

This is one portion of a Qualified Electrical Worker's studies that could mean the difference between life and death. Study the references carefully and remember that practice makes perfect. The best case scenario is to never be faced with having to do a rescue, but, hopefully, Qualified Electrical Workers will be prepared in case they ever do.

The instructor is allowed and encouraged to vary the way he or she has apprentices perform the field proficiency part of this lesson.

Learning Objectives:

After completing this lesson, you will be able to:

1. List the four basic steps in pole top rescue.
2. Describe the steps that should be followed when climbing to the rescue position.
3. List the steps required to lower a victim to the ground from the top of a substation transformer.
4. Describe basic CPR.

Lesson 11: Bucket Rescue

Introductory Information:

The crew on the ground can accomplish retrieval of a worker from a truck quickly and safely with proper planning before work is started and with prompt action. Should an accident happen and a worker become injured or unconscious while working in a bucket, every second counts.

This lesson will cover basic bucket rescue and aerial lift procedures. Each employer should have a program in place for employee rescue in the event a worker becomes incapacitated while working in a bucket. Qualified Electrical Workers should become familiar with the capabilities and controls of the equipment they will be working with and the information contained in this lesson.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain how critical time is in a bucket rescue.
2. Identify the need for personal safety in bucket or aerial platform rescue.
3. Describe the four acceptable methods of bucket rescue.

Lesson 12: Personal Protective Grounding – Grounding in Substations

Introductory Information:

Substations present a unique grounding situation. Substations contain many objects that can be used for connecting personal protective grounding equipment. However, seldom is an entire substation deenergized. Close spacing between energized and deenergized items, induced voltages, and currents are common; fault current levels are typically larger at a substation than at a remote worksite. Grounding at a substation usually requires larger clamps and cables, which are heavier and more difficult to use.

In substations, the magnitude of fault current is a major consideration when grounding. The mechanical forces that result from such high currents may physically break the clamps before any adverse effect from the heating due to current flow is seen.

Learning Objectives:

After completing this lesson, you will be able to:

1. Recognize the different grounding requirements between substation work and remote site work.
2. Know the importance of placing the grounds close to the worker.
3. Be able to recognize the hazards from the current and voltages present.

Lesson 13: Grounding and Protective Grounds

Introductory Information:

Qualified Electrical Workers are frequently “grounding” (“earthing” in some English-speaking countries) to make situations safer. For example, workers may apply personal safety grounds to allow safer work on an isolated line. Or they may ground stringing blocks and ground gradient matting for safer stringing operations, or ground trucks for safer boom operation near live lines. System grounding may be needed to keep the electrical system operating safely. Good grounding is essential for the safe operation of an electrical system, but it is not always obvious to the worker. Ground rods must be installed and connections made as specified.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the reasons for grounding electrical circuits and equipment.
2. Identify hazards involved with system grounding.
3. Identify the factors that affect the resistance of a ground path.

Lesson 14: Working Outdoors

Introductory Information:

The electrical industry is a high hazard industry, specifically the work on and around general equipment and distribution and transmission lines. To protect oneself and one's coworkers on the job, it is important to understand the different hazards a Qualified Electrical Worker may encounter. The majority of work will be performed outdoors, exposed to weather and nature at its worst. Nature's creatures and conditions increase the hazards faced by Qualified Electrical Workers. Learning how to protect oneself from the elements and creatures outdoors will prove valuable.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain how weather conditions affect the job.
2. Explain where to find information on safety when working in different weather conditions.
3. State how to protect oneself and one's coworkers when encountering different weather conditions.

SUBSTATION APPRENTICESHIP

1ST YEAR – LEVEL 5

LESSON LEARNING OBJECTIVES

Lesson 1: Identify Some Basic Tools of the Trade

Introductory Information:

One of the first things that an apprentice must do is to become familiar with the tools of the trade. Qualified Electrical Workers working with these tools should know the correct names for them, as well as how to properly use them. It is a good idea to review the tools that may have been used in previous Groundman experience, and to help others with proper identification.

Quite often one tool might have more than one name; a proper name plus one or more "trade" or "slang" names. Qualified Electrical Workers should know the proper name as well as any "trade" name(s) used in their area. Sometimes tools will be called by different names in different areas. Knowing the proper name for the tool will help to determine what tool is being referenced.

Identify as many of the tools as possible. Once again, do not hesitate to ask for assistance. After all of the tools have been identified, review them until each tool can be accurately recognized.

Apprentices' knowledge of tools in the field will continue to expand as they are introduced to new tools. If the name of a tool is unknown, ASK!

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the more commonly used hand tools of the electrical industry.

Lesson 2: Use and Care of Hand Tools

Introductory Information:

When entering the electrical field, it will become clear that a large number of hand tools are used to perform job tasks. It is necessary to properly identify the hand tools that are required to perform the job. The various tools are all designed to help complete the task at hand. It is critical that employees use the hand tools in a safe manner.

Become familiar with all the tools needed in the field and their safety requirements. Many injuries result from defective tools, or using tools improperly. Safety is always a concern and working with worn or improperly cared for tools is a workplace hazard. The U.S. Consumer Product Safety Commission reported that more than 100,000 injuries requiring hospital treatment due to the misuse of common hand tools occur each year. Be advised that the proper Personal Protective Equipment (PPE) must also be used. Properly using tools will create a safe work environment not only for the individual, but for those working in the area as well.

This lesson contains some general rules for the safe use and care of tools. Understanding how to use hand tools correctly can eliminate injury and lead to a long, productive, and enjoyable career.

Another factor, not as serious as injury but still important to consider, is the high cost of hand tools, both personal and company supplied. The improper use of hand tools can lead to premature breakage, which can cost employees or their employer a great deal of money.

One sure sign of a good mechanic is demonstrated in the use and care of his or her hand tools.

Learning Objectives:

After completing this lesson, you will be able to:

1. Demonstrate (on the job) the proper selection, safe application, and care for all tools of the trade.
2. Discuss how important proper tool usage is to safety, productivity, and the tool's life span.
3. Describe how to use basic hand tools properly.
4. List defects that make a tool unusable.

Lesson 3: Protective Line Devices – Care and Use

Introductory Information:

Rubber protective devices should be kept dry, clean, and in first-class condition, but do not be afraid to wear them out. Cover all energized conductors and grounds that Qualified Electrical Workers could possibly touch, reach, or fall into. Today many fiber and plastic line guards are being used on distribution and lower transmission voltages. They should be given the same care and consideration as rubber goods. **Remember: line guards are to prevent accidental contacts only.**

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe how rubber protective equipment and the Minimum Approach Distance relate.
2. Describe how to apply various insulating equipment over energized equipment.
3. Describe how line hoses are used.
4. Explain how ozone cutting of rubber equipment takes place in the field.
5. Care for and use rubber goods and PPE.

Lesson 4: Good Housekeeping

Introductory Information:

Whether a citizen, union member, or tradesman, it is most important to have one's house in order.

It is necessary to maintain awareness of the surroundings in order to determine what can be done to promote harmony, safety, efficiency, and the public image of the craft and the industry.

Learning Objectives:

After completing this lesson, you will be able to:

1. List recommended considerations for establishing a safe, productive job site.
2. Recognize the need for neatness on the job site.
3. Explain how good housekeeping procedures affect the work environment.

Lesson 5: Powered Equipment Safety – Compressors and Portable Generators

Introductory Information:

Two pieces of equipment used in electrical construction work are air compressors and portable generators. Air compressors provide compressed air for running pneumatic tools, such as jackhammers or drills. Compressed air also poses a hazard due to the force behind the air. Respect the dangers of compressed air. Always wear hearing protection when working with compressed air; once permanent hearing loss begins, it cannot be reversed.

Generators make our work in the field easier, allowing us to use power tools. Comply with all electrical safety precautions when working with a generator. In addition, only use a generator in an open, well-ventilated area, never inside. Deadly exhaust and gas fumes can overtake an individual in just a few breaths. Never connect a generator directly to household wiring. A dangerous "back-feed" situation could arise and threaten Qualified Electrical Workers many miles away working on what they think is a dead line. There should be some type of open point between the generator and the utility company's meter before the generator is connected and started.

Learning Objectives:

After completing this lesson, you will be able to:

1. List the electrical hazards associated with generator use.
2. Describe the hazards associated with exhaust and gas fumes.
3. State the hazards associated with compressed air.
4. State where and how to use a generator.
5. Locate the OSHA requirements for noise levels and exposure limits.

Lesson 6: Powered Equipment Safety – Underground

Introductory Information:

Power equipment is necessary for efficient underground construction; however, it does pose many hazards to the crew. Crew members should have an understanding of the equipment used on the job site. Safety on and around any power equipment is vital, as well as the proper and safe operation of the equipment. The job site conditions such as terrain, access, and utilities all raise concerns of safety. A "One Call" must be performed before any ground is broken. This needs to be done so the location of any underground utilities are known. There is a standard number. To call this number, simply dial 811. This could be the difference between life and death. Most apprentices are not given the responsibility of operating equipment early in their career. However, they do need to understand how to work around equipment. Communication with the equipment operator is key to safety on the job site.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss the safe working distance from equipment.
2. Discuss how to react to utility damage safely.
3. Maintain and service an underground machine as per the operator's manual.
4. State the importance of the operator's manual.

Lesson 7: Digging Holes and Trenches

Introductory Information:

This lesson is of a practical nature and is intended to broaden the Qualified Electrical Worker's view of doing manual tasks. There is little doubt that Qualified Electrical Workers can learn to do this type of job without written lessons. However, this lesson will assist in the learning curve and give some background knowledge about how the job is done before being assigned to do it. Also, learning how to approach this type of work in a safety-conscious manner will be discussed.

Needless to say, when using power equipment to dig or bore, Qualified Electrical Workers must be mindful of what might be buried in the work area. It is not uncommon to confront obstructions, such as power cables, communication cables, gas lines, water lines, and drain tiles. Additionally, Qualified Electrical Workers must call 811 for a one call before digging anywhere. Furthermore, most utilities require the first three feet to be dug by hand. By observing proper procedures, obstruction damage and personal injury can be avoided.

Learning Objectives:

After completing this lesson, you will be able to:

1. List methods used in digging, trenching, and boring.
2. Discuss and observe safety precautions that should be taken whenever digging or trenching.
3. Perform pole hole digging and sizing with power and manual methods.

Lesson 8: Ladders/Step Bolts

Introductory Information:

Apprentice Electrical Workers are accustomed to working at great heights on poles and towers. It is important to not let this fact lead to ignoring the possibility of injury resulting from the use of ladders. Many people are killed or injured each year as a result of the misuse of ladders.

This lesson contains information on the selection, use, and care of extension ladders. Also covered are key points of safety when working from hook ladders and climbing fixed ladders and step bolts on structures.

Learning Objectives:

After completing this lesson, you will be able to:

1. Select the right ladder for a job.
2. List what needs to be checked on a ladder before it is put into use (including hook ladders).
3. Explain how to use ladders properly on the job site.
4. Describe how to care for ladders.

Lesson 9: Ropes, Knots, Hitches, and Splices

Introductory Information:

Rope plays a very important role in the work of a Qualified Electrical Worker. To use it properly, Qualified Electrical Workers should understand its strength, deterioration rate, safety factor, dielectric properties, inspection requirements, use, and care. There are few experienced Qualified Electrical Workers who have not at one time or another seen ropes fail, with alarming or serious results. By properly studying rope and how to tie knots properly, similar experiences can be avoided.

Remember: When a rope breaks, a mistake in judgment has been made.

This lesson can be taught in the classroom, but more will be learned on the job. Talk with a foreman and a fellow Journeyman Electrical Worker and ask them to share their experience and knowledge.

In too many cases, Qualified Electrical Workers become so familiar with rope that they tend to judge safe loading in terms of rope failure that they have seen at some previous time. This practice may not allow enough of a safety factor.

Remember: Never under-rig.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain the advantages and limitations of various knots, hitches, and splices and be able to properly tie them.
2. Explain the properties of different types of fiber rope and select the proper rope for a given job.
3. Discuss how to properly care for rope.

Lesson 10: Use and Operation of Blocks

Introductory Information:

Due to the heavy mechanical lifting requirements of the electrical construction industry, it is important that Qualified Electrical Workers have a working knowledge of the uses and operations of blocks. This means each apprentice needs to become familiar with the different types of blocks, the function and various components of blocks, and the design safety factors used when working with blocks

It is also important that the apprentice become familiar with particular applications of the various blocks so that the right block is selected for any given task.

Learning Objectives:

After completing this lesson, you will be able to:

1. Calculate safe working loads and rigging methods for blocks.
2. Identify the various types of blocks used in electrical construction.
3. Determine the proper application of blocks.

Lesson 11: Slings and Chokers

Introductory Information:

Due to the heavy mechanical lifting requirements of the electrical construction industry, it is very important that Qualified Electrical Workers have a working knowledge of slings and chokers.

A thorough understanding of slings and chokers is essential. This means familiarity with the different types of slings and chokers, the function of each component, and the design safety factor of each type of sling and choker.

Full recognition of the inherent use potential derives from a realization of the great number and wide variety of slings and chokers available for general and special operating needs. It is of special importance that the user becomes familiar with the particular applications of the various slings and chokers in order to make the right selection for a given task.

Learning Objectives:

After completing this lesson, you will be able to:

1. Determine safe working loads and rigging methods for slings and chokers.
2. Determine the proper application of slings and chokers.
3. Identify the various types of slings and chokers that are commonly used in the electrical construction industry.

Lesson 12: Rigging Tools and Rigging Equipment

Introductory Information:

Due to the heavy mechanical lifting requirements of the electrical construction industry, it is very important that Qualified Electrical Workers understand all the components involved in heavy lifting and rigging.

A thorough understanding of rigging hardware components is essential. This requires familiarity with the different types of hardware, the function of each component, and design safety factors.

An awareness of the large number and wide variety of hardware components available for general and special operating needs is essential. It is of utmost importance that the user becomes familiar with the applications of the various hardware components in order to make the right selection for a given function.

Wire rope clips, shackles, hooks, wedge sockets, eye bolts, turnbuckles, rings and links, spreaders, and equalizer beams will all be covered.

Learning Objectives:

After completing this lesson, you will be able to:

1. Determine the proper application of rigging hardware.
2. Determine safe loads for equipment.
3. Identify rigging hardware components.

Lesson 13: Powered Equipment Safety/Digger Derricks

Introductory Information:

Digger derricks are commonly used in the electrical construction industry, not only for digging holes and setting poles, but often also to handle other heavy materials used in day-to-day work.

Safe operation of digger derricks is key to preventing injury and material or equipment damage. Qualified Electrical Workers have been injured or killed when they have failed to recognize hazards or follow safety rules and manufacturer's guidelines.

This lesson will help build a solid foundation to become skilled and knowledgeable in working on or around digger derricks. The next step is to apply what is learned in this lesson "on the job" by becoming familiar with the operator's manual and the equipment one will be operating or working around.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss the safe operation of digger derricks.
2. State associated hazards with the operation of a digger derrick.
3. Interpret load charts and manuals.
4. State the location of safety labels and inspection points found on a digger derrick.

Lesson 14: Hand Signals

Introductory Information:

Hand signals used in line work are very important and should be clearly understood by all involved. This requires the standardization of signals. In many instances, messages must be communicated near noisy equipment, in high winds, or over great distances. These conditions make audible signals ineffective and subject to misinterpretation, which could cause a serious accident.

Visible signals should be used when possible. The work of the crew will be easier, safer, and more orderly if proper hand signals are used. Persons giving signals (instructions) to operators or helicopter pilots must be clearly visible at all times.

Signaling is a very exact and precise procedure. It should only be done by those who take it seriously and are willing to accept the associated responsibility.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the importance of hand signals in line work.
2. Demonstrate how to give basic hand signals for material handling.
3. Demonstrate the ability to follow hand signals when given.

SUBSTATION APPRENTICESHIP

1ST YEAR – LEVEL 6

LESSON LEARNING OBJECTIVES

Lesson 1: The Electric System

Introductory Information:

Learning about the "electric system," both as a whole and in terms of the different components that form the system, will lead to a better understanding of the various systems that Qualified Electrical Workers work on daily as well as how Qualified Electrical Workers contribute in supplying power to customers.

Details of the electric system components are covered throughout the training program.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the distribution system.
2. Describe the transmission system.
3. List the different components that are involved in the electric system.
4. Describe different types of generating stations.

Lesson 2: Introduction to Substations

Introductory Information:

With approximately 100,000 substations in the United States, every Qualified Electrical Worker should have a solid understanding of substations, their functions, equipment, and safety procedures involved. Study this information carefully, as most Qualified Electrical Workers will be working in substations at some point in their career.

Learning Objectives:

After completing this lesson, you will be able to:

1. List two methods used in substations to interrupt an arc and thereby protect a feeder.
2. List two types of substations.
3. Discuss three types of equipment found in substations.

Lesson 3: Substation Construction – Foundations

Introductory Information:

The placement and security of a foundation for the heavy equipment and structures in a substation requires very precise and quality work. Much of the hardware in a new substation is modular, and the parts will fit only if the foundations are installed accurately.

Learning Objectives:

After completing this lesson, you will be able to:

1. Build a form to specifications.
2. Install anchor bolts and rebar to specifications.
3. Pour concrete to specifications.
4. Finish the concrete to specifications.

Lesson 4: Working in Excavations and Trenches

Introductory Information:

With the advent of URD, safe practices in excavating and shoring have become increasingly more important. The weight of collapsing walls in a trench or excavation can cause injury or death to workers. Awareness of these dangers and compliance with safe work practices will do a great deal to keep all concerned from becoming statistics. Qualified Electrical Workers must be familiar with safety requirements when working in and around excavations and trenches. Keep in mind that in addition to cave-in hazards, other hazards, such as hazardous atmospheres, may also be present in excavations.

Proper planning prior to the start of the job is one of the most important factors in reducing worker injuries and fatalities related to excavations and working in trenches. The job-site briefing is an important part of keeping workers safe when working in excavations and trenches.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify hazards associated with excavations and trenches.
2. Discuss the duties of a competent worker as related to excavations and trenches.
3. Discuss OSHA's Subpart P safety requirements for excavations and trenches.

Lesson 5: Excavating the Trench

Introductory Information:

With the advent of URD, safe practices in excavating and shoring have become increasingly more important. The collapsing walls of a trench can be a major source of injury or death to workers. An awareness of these dangers and compliance with safe work practices will do much to keep all concerned from becoming statistics. The purpose of this lesson is to introduce OSHA safety requirements when working in and around trenches. Keep in mind that in addition to cave-in hazards, other hazards such as hazardous atmospheres may also be present in trenches.

Trenches may be very narrow like the type that might be used to lay in a single run of URD, or they may be wide enough to lay in entire duct runs as in a substation.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss the hazards associated with trenches and understand how to protect workers against them.
2. Classify soil types commonly found in trenches.
3. Discuss OSHA 1926, Subpart P safety requirements for trenches.

Lesson 6: Laying Conduit/Building Duct Banks

Introductory Information:

Cable installations are expensive; therefore, every part of an installation should be completed thoroughly and carefully.

Qualified Electrical Workers should know how to install conduit and how duct banks are constructed. Laying conduit properly is an important part of the underground distribution system. Proper installation will lead to many years of trouble-free operation.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify different types of conduit systems.
2. Apply proper methods for installing a duct bank.
3. Install conduit to the proper depth and use proper backfill methods.

Lesson 7: Manholes and Handholes

Introductory Information:

Manholes play a very important part in the electrical system. Cables are terminated or spliced in manholes; equipment such as transformers or switches may also be set in manholes. Manholes help keep cables out of sight when poles and towers are not desirable.

The construction of manholes, which has been made much easier with the advent of precast-concrete manholes, is an important part of a Qualified Electrical Worker's job. Proper setting of the manhole and termination of the conduit are critical to a correct installation. Pay particular attention to the construction of the manhole, including how the different sections are set and how the excavation area is backfilled.

A manhole with the pulling eyes in the wrong place or with the opening poorly located can be very difficult to work on.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the purpose of manholes and vaults.
2. Explain proper construction techniques in the building of a manhole or vault, including placement of a precast structure.

Lesson 8: Trench Encasements, Backfill, and Compaction

Introductory Information:

Trench encasement, backfilling, and compaction are normally considered the civil engineering part of installing underground cables. Some systems may be as simple as a single-phase service to a single residential customer, or as complicated as installing a large duct bank for multiple runs of primary cable under city streets. Qualified Electrical Workers should be familiar with the practice of trench encasement, backfilling, and compaction. Every location is different in soil makeup and type of traffic the trench may be exposed to. The engineering specifications should be followed in order to guarantee a job that will maintain its integrity for the life of the cable.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the proper way to tamp a trench containing a duct bank or conduit.
2. Discuss the types of concrete used for duct bank encasement.
3. State three types of material that should not be part of the backfill in a trench.

Lesson 9: Cable Types

Introductory Information:

Qualified Electrical Workers who progress in the electrical industry will undoubtedly see an increase in the number of underground systems. Proper handling and care of cable have a high priority with power companies. It is an expensive installation and difficult to repair, so the utmost care and understanding must go into its installation.

New technologies have helped develop many new types of cable insulations. These new insulations have unique characteristics and applications. What type of material to use is a consideration many Qualified Electrical Workers face.

Knowledge of the types and construction of cables, including an understanding of the different types of cables available and the cables' proper applications, is a valuable asset to both the contractor and the industry.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the different types of stranded conductors.
2. Explain the different types of insulations used.
3. Identify the different components used in shielded and non-shielded cables.

Lesson 10: Substation Construction – Underground Power Cables

Introductory Information:

Most distribution feeders coming out of a distribution substation are underground cables, especially for crowded situations when there are more than three feeders that need to exit out of a substation and connect to lines in various locations outside of the substation fence.

It is not uncommon for the source circuits, especially in urban situations, to enter a substation as underground cable. It is essential to recognize the fragile nature of underground cable and to become proficient with work methods involving pulling/laying, splicing, and terminating cable.

Learning Objectives:

After completing this lesson, you will be able to:

1. Recognize the fragile nature of underground cable.
2. Describe the proper methods of pulling and laying cable.
3. Describe the proper methods of splicing and terminating cable.
4. Work safely around cables.

Lesson 11: Pulling Cables

Introductory Information:

Pulling cable is an important part of the job. Cable that is not pulled properly stands a very good chance of being damaged. A common cause of underground cable system outages is damaged cable resulting from improper handling and installation. Minor damage may not show up immediately, but it can lead to premature failure.

Cable is expensive, and any damage inflicted while pulling between manholes, into substations, or into transformers and switchgear, must be avoided.

Pay close attention to the general practices and cautions outlined in the reference material. Always work safely and be aware of the power equipment in the work area.

Learning Objectives:

After completing this lesson, you will be able to:

1. Set up the proper rigging and identify the different equipment used in pulling cable.
2. Understand and be able to follow general pulling practices and cautions.
3. Identify and follow proper safety techniques used in pulling cable.

Lesson 12: Installing Cable in an Underground Vault/Manhole

Introductory Information:

After the cable has been safely pulled into a vault or manhole, the cable must be properly positioned, spliced, or terminated in order to ensure a quality job. Knowing some of the techniques used to properly pull cable into vaults or manholes, and how to place and terminate cable, is essential. Every vault or manhole is different in the number of cables brought into it and in what is to be done to the cables once they are in the vault or manhole. Qualified

Electrical Workers should make a careful study of the engineer's requirements for the vault or manhole that they are working in.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss the safety items used to prevent overstressing cable when being pulled in.
2. Explain how a blower is used when working in an enclosed space.
3. Discuss the different types of racks used in vaults/manholes to hold cables in place.

Lesson 13: Substation Construction – Ground Grids

Introductory Information:

To provide good service to customers, a good ground must be part of the electrical system. Unfortunately, the earth does not provide a consistent electrical ground in all locations because of its makeup; there are different levels of conductivity when the ground is made up of rocks or loam. To make up for this inconsistency, and to provide a known level of electrical ground, substation ground grids are built to tested and known levels of resistivity. This allows engineers to build systems to known values, and provides customers with quality electrical service.

Qualified Electrical Workers will benefit from an introduction to substation grids, concentrating on how to physically lay out and connect the substation grid. Qualified Electrical Workers should be able to recognize the elements which are required to maintain a safe grid. For good step-by-step substation design procedures, review IEEE Standard 80.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss proper grounding and location of a substation fence.
2. Identify the connectors that are typically used when constructing a substation grid.
3. Explain two methods that might be used to lower ground resistance when installing a substation ground grid.

Lesson 14: Exothermic Welding

Introductory Information:

Because of the high temperatures and other safety issues associated with this type of welding, every worker involved in exothermic welding should be well-trained in the procedures involved.

Learning Objectives:

After completing this lesson, you will be able to:

1. State three safety procedures associated with applying an exothermic weld.
2. List three of the technical procedures required to make a successful exothermic weld.
3. List four metals or combinations of metals where exothermic welding can be used in a substation.
4. State why exothermic welded connectors are superior to squeeze-on connectors.