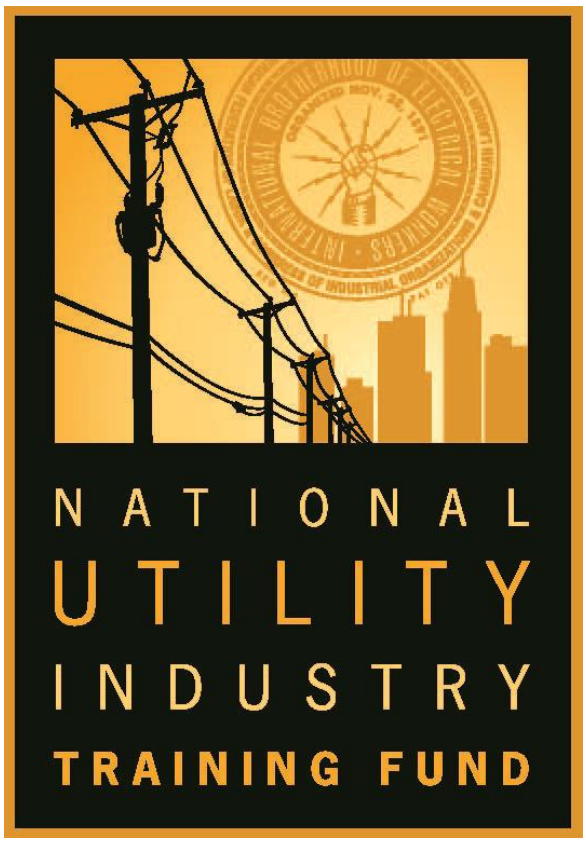
ELECTRICAL TRAINING ALLIANCE OUTSIDE LINEMAN APPRENTICESHIP

Second Year
Lesson Learning Objectives



Outside Lineman Apprenticeship

Year 2

2nd Year – Level 1

Learning Objectives

The course opens with lessons that cover organizational topics such as the National Program, the IBEW Constitution, Parliamentary Procedure and How it Works, and Understanding Local Union Bylaws. It then covers Professional Personal Conduct, Absenteeism, Working Outdoors, and Emergency Response. The course closes with lessons on Reviewing the Applications of DC Theory, Fundamentals of Alternating Current, Understanding How the DC Generator Works, and Understanding the Design and Function of AC Generators.

Lesson 1 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 2 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 bylaws, but under no circumstances can bylaws conflict with or overrule the Constitution.

A good union member is an informed union member. Take pride in the union and—most importantly—take part in the union's activities.

Copies of the Constitution are available at local unions. For questions that require the IBEW Constitution Reference, include the Article and Section only (not subsections), as indicated in the dropdown list.

Learning Objectives

After completing this lesson, you will be able to:

1. Demonstrate an understanding of the structure of the IBEW.
2. Show a basic knowledge of what items are covered in the IBEW Constitution.
3. Use the Constitution to answer specific questions pertaining to the rules and regulations that it establishes.

Lesson 3 Parliamentary Procedure and How It Works

Introductory information:

Many times, a member comes away from a meeting feeling that the meeting had not been properly conducted or that he or she had not been given proper treatment on the floor. Often this feeling is the result of that member's lack of knowledge of procedure. The member may not know how to present a motion.

Obtain a copy of Robert's Rules of Order and study it. The information gained from reading the book and group discussion should help to instill a working knowledge and understanding of how Parliamentary Procedure works.

Learning Objectives:

After completing this lesson, you will be able to:

1. Demonstrate a knowledge and understanding of parliamentary procedure.
2. Understand the responsibility, authority, and role of the chairperson.
3. Abide by parliamentary rules when granted the privilege to attend and participate in local union meetings.

Lesson 4 Understanding Local Union Bylaws

Introductory information:

Local union bylaws are the rules under which local unions operate. They must not conflict with the IBEW Constitution and they should establish the guidelines for conducting the business of the local union.

Members should take an active part in the affairs of their local union. To do so, they should acquire a copy of the Constitution, their union bylaws, and the negotiated working agreement. Becoming familiar with and understanding these documents will help them to become informed participants at union meetings.

Note: Answer the questions using the bylaws provided in the Reference: Understanding Local Union Bylaws (see CourseWare). Do not use any other bylaws as a reference.

The bylaws provided in Reference are generic in nature. They provide a standard reference regardless of local union affiliation. These generic bylaws were developed using pattern language provided courtesy of the International Brotherhood of Electrical Workers. They are not meant to represent the bylaws of any particular local union and are to be used for training purposes only

Learning Objectives:

After completing this lesson, you will be able to:

1. Know what topics are addressed in local union bylaws.
2. Use the bylaws to answer questions regarding local union policies and procedures.
3. Explain how the bylaws affect the operation of the local union.

Lesson 5 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 6 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.

Lesson 7 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.

Lesson 8 Emergency Response

Introductory information:

Proper planning is vital in saving lives and minimizing property damage during an emergency. Effective safety and health programs should include the development and maintenance of Emergency Action Plans for emergencies such as personal injury, fires, severe weather, explosions, chemical spills, and accidental releases of toxic gases.

Despite all efforts to provide a safe and healthy workplace in the electrical industry, fatalities and serious accidents do happen. There are still several employers in this industry who do not have Emergency Action Plans or do not enforce them. It is important to understand what an Emergency Action Plan is and where to find it in order to protect both oneself and one's coworkers on the job.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain the basics of an Emergency Action Plan.
2. Know where to find the employer's Emergency Action Plan.
3. Know how to protect oneself and one's coworkers if the employer does not have an Emergency Action Plan.

Lesson 9 Introduction to 1910.269, Electric Power Generation and Transmission, and Distribution

Introductory information:

OSHA 1910.269 is a performance standard to address employees who are directly involved with electrical power generation, transmission, and distribution. The standard includes provisions for enclosed spaces, hazardous energy control, working near energized parts, grounding for employee protection, working on underground and overhead installations, line-clearance tree trimming, work in substations and generating plants, and other special conditions related to these types of operations.

Every Qualified Electrical Worker should carefully study the complete 1910.269 standard.

Learning Objectives:

After completing this lesson, you will be able to:

1. Determine if an electrical installation or work practice is covered by the OSHA 1910.269 standard.
2. List the major components of the OSHA 1910.269 standard.
3. Identify important safe work practices contained in the OSHA 1910.269 standard.
4. Determine the difference between Subpart V of the Construction Standard and 1910.269.

Lesson 10 Reviewing the Applications of DC Theory

Introductory information:

Electrical theory principles and their functions will be reviewed. Understanding the basic principles and concepts learned in the study of DC theory are applied to the study of AC theory.

Basic DC theory calculations are reviewed, and there should not be any problems continuing with the study of AC theory. If difficulties are encountered in solving problems, a review of the information dealing with DC theory should help solve them.

Learning Objectives:

After completing this lesson, you will be able to:

1. Define voltage, current, resistance, and power.
2. Describe how voltage, current, and resistance function in series and parallel circuits.
3. State the basic Ohm's Law formulas as they apply to DC Theory.
4. Work a variety of DC Theory mathematical problems correctly, which will aid in the study of AC Theory.
5. .

Lesson 11 Comparing Direct Current to Alternating Current

Introductory information:

Direct current (DC) is current that flows in only one direction. Current that changes direction periodically is known as alternating current (AC). Practical applications for each type of current are seen on the jobsite every day. The convenience of battery operated drills is courtesy of direct current. In addition, alternating current is what powers the temporary lighting so that work is not completed in the dark.

Both AC and DC have distinct advantages. However, when there is a need to transmit large amounts of power over long distances, AC is the preferred choice. The reason for this has to do with money. Transformers can step up AC voltages to very high levels. Knowing that power is equal to voltage times current, it is easy to see that by using a higher voltage, the same amount of power can be delivered at a lower current. The lower current results in less heat loss, which permits the use of

smaller conductors for the transmission lines. Using smaller wires results in a significant cost benefit for the supplier which in turn makes electricity more affordable for the consumer.

The biggest single advantage of AC is that it can be transformed from one voltage to another; that is, a transformer can step voltage up or down. Higher voltages are better for transmitting electricity over long distances. This is because the higher voltage can transmit the same amount of power at a lower current value (remember that $P = EI$). Consequently, there is less heat loss (I^2R), and smaller, less expensive wire may be used. Higher voltages would be dangerous inside the home or the workplace; therefore, transformers are used to step the voltage down to lower, safer levels. DC also has some advantages; however, AC is used for the overwhelming majority of major electrical energy supply systems.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the distinct characteristics of alternating and direct current.
2. Apply Ohm's Law to understand the advantage of using alternating current for power distribution.
3. Know the definition of terms used to express the characteristics of AC waveforms.
4. Understand how the values of AC waveforms are represented by the sine wave.

Lesson 12 Fundamentals of Alternating Current

Introductory information:

An understanding of the principles of alternating current is necessary if one is to understand the operation of distribution equipment.

As an apprentice and as a Qualified Electrical Worker, most work is with the use of the sine wave, which is only a graph of instantaneous values of voltage in an alternating-current system. These values are what they are because a rotating machine generates the voltage.

Remember, the current created by a generator is the result of the electromotive force (EMF) developed by the generator. Voltage is defined as electromotive force. It is force that pushes the electrons through a wire and is often referred to as the electrical pressure.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe how an AC waveform can be represented graphically as a sine wave.
2. Define the terms cycle, frequency, period, alternation, sine wave, and instantaneous values.
3. Mathematically calculate values of AC parameters including effective value/voltage, average value/voltage, maximum value/voltage, and peak-to-peak values/voltages.

Lesson 13 An Introduction to 3-Phase Systems

Introductory information:

In the power generation, transmission, and distribution field, there is no such thing as a single-phase system. All power is generated and handled as 3-phase power. Often in distribution work, Qualified Electrical Workers will work with one phase and a neutral and refer to this as single-phase, but this is really part of a 3-phase system. Three-phase systems are utilized due to their efficiency and economy. Understanding 3-phase systems and their current and voltage relationship is essential to working with 3-phase systems.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the relationship between the voltages or currents in different phases of a 3-phase power system.
2. Explain the physical differences between wye and delta 3-phase connections.
3. Calculate current and voltage parameters of both wye and delta 3-phase systems.

Lesson 14 Understanding How the DC Generator Works

Introductory information:

Due to its nature, direct current has some applications that make it superior to alternating current. DC can be used to drive motors for precise control. DC motors are used for many industrial applications, such as the drives for manufacturing equipment, printing presses, metro car propulsion, and locomotives.

Alternating current is normally available at most sites. When DC is required, Qualified Electrical Workers will often encounter DC generators to provide the desired power.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the major parts of the DC generator.
2. Describe the principles and operation of the DC generator.
3. List the different types of losses in a generator.

Lesson 15 Understanding the Design and Function of AC Generators

Introductory information:

A review of the DC generator explains that all rotating machinery used for generation produces a sine wave and alternating current. The DC generator uses a commutator, so that the current is always removed from the windings, and so that the polarity remains the same. The commutator is also a limiting factor in DC generation in that it cannot commute very large currents necessary for modern society.

Most electrical power produced today for the world economies is alternating current. Most of this electricity is produced as 3-phase power.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the operation of AC generators.
2. Identify key parts of the AC generators and their functions.
3. Mathematically determine the relationships between RPM, frequency, and the number of poles.

2nd Year - Level 2

Learning Objectives

Level II focuses primarily on transformers. It opens with lessons on test instruments, and then covers transformer construction, characteristics, operation, polarity, tap changers, installation, load checks, and protection. The last lesson in the course will teach students about vectors.

Lesson 1 Introduction to Test Instruments

Introductory information:

Measuring quantities is not new technology. People have been developing standards and methods for taking measurements for thousands of years. Modern culture uses a sophisticated system of benchmarks and test instruments to describe the physical world. Today, almost any task requires the use of measurement concepts, although some trades, particularly the electrical trade, use measuring tools in nearly every procedure.

Qualified Electrical Workers must be knowledgeable in the applications, safety considerations, procedures, potential errors, proper maintenance, and standards and procedures of the test instruments they use.

Although Qualified Electrical Workers can use test instruments ranging from relatively simple to very complex, all demand a thorough understanding of the instrument and its safety requirements.

Learning Objectives:

After completing this lesson, you will be able to:

1. State several precautions required to properly care for test instruments.
2. Discuss the historical development of measuring standards and methods.
3. Discuss the use of safety labels, procedures, equipment, and standards as they apply to the use of test instruments.
4. Identify the causes of common measurement errors and the techniques used to reduce them.

Lesson 2 General Use Test Instruments

Introductory information:

Many test instruments are highly specialized pieces of equipment that are used only by those trained in specific fields. However, there are several types of common test instruments that can be used safely by anyone and can provide useful information in a wide variety of situations. These include various types of instruments to indicate or measure voltage, current, resistance, or a combination of these and other quantities.

Technicians must be knowledgeable of the general procedures on how to safely use voltage, current, and resistance test instruments by themselves as tools for diagnosing relatively simple electrical problems, and as a starting point in complex situations before more specialized equipment is required. The relative advantages and disadvantages of each test instrument are important for the technician to understand when selecting the right instrument for a particular job.

These general use test instruments are so fundamental to most types of electrical and maintenance work that they can be found almost anywhere. Understanding what they are and how they are used is important to solving problems in the field.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the different types of voltage and current test instruments and their relative advantages and disadvantages.
2. Understand how to safely use various voltage or current test instruments to identify electrical power problems.
3. Understand the different types of voltage and current and the terminology used to describe them.
4. Identify the different types of multimeters and understand how their features are useful in troubleshooting.
5. Understand the concepts of resistance and continuity and safely use an ohmmeter or megohmmeter.

Lesson 3 Introduction to Transformers

Introductory information:

Electrical distribution transformers and Qualified Electrical Workers have a history that goes back over 110 years. Given this long history, improper transformer connections and difficulty troubleshooting transformers remains the most often-cited reasons for damage to customer property.

The transformer makes the electrical industry possible with its ability to step up voltage at the power plant and step it down at a substation or at the customer's location. In order to understand transformer connections and the voltages taken from them, it is important to understand the basic principles that make a transformer work.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify different types of transformers.
2. Explain how a transformer coils and core function.
3. Describe the basic theory of electromagnetic induction.

Lesson 4 Transformer Construction

Introductory information:

Memorizing which wire goes to which transformer bushing for a certain voltage adds to the mystery of transformers, and can sometimes lead to Qualified Electrical Workers being hurt when a different method of wiring is encountered. A careful study is needed to dispel any misunderstandings surrounding transformer installations and connections. An understanding of what is inside a transformer tank is fundamental in giving a Qualified Electrical Worker the necessary information to be able to work with transformers in a safe and skillful manner.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe factors that contribute to transformer heating.

2. Draw and explain the internal leads brought out from transformer coils.
3. State factors that contribute to transformer losses.
4. Describe, identify, and explain the material and components used in a transformer.

Lesson 5 Transformer Information Characteristics

Introductory information:

Knowing what the information on a transformer nameplate means can be the difference between a routine job and a disaster. Manufacturers and electric companies keep extensive records on every transformer, but it is up to the Qualified Electrical Worker to properly interpret the information given to him or her. Transformers may look identical, but only by looking at the nameplate can one be sure of what is in the can.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe five items found on transformer nameplates.
2. State coil capacity of transformers connected in series and parallel.
3. Differentiate between internal transformer coils in series or parallel.

Lesson 6 Transformer Operation

Introductory information:

Electrical transformers are a key piece of equipment used to provide electrical power to customers. In order to have a long, safe, and successful career as a Qualified Electrical Worker, it is important to have a firm understanding of how transformers operate.

Get into the habit of inspecting every transformer the crew takes out or removes from a job. The Foreman and Qualified Journeyman Electrical Worker are valuable resources in all aspects of training, but especially in learning to understand transformers.

When properly selected and installed, transformers will deliver many years of effective service. It is only when Qualified Electrical Workers become complacent about transformers that accidents happen and the customer's equipment is damaged.

Learning Objectives:

After completing this lesson, you will be able to:

1. Differentiate between the functions of a potential and a current transformer.
2. Describe and apply transformer ratios.
3. Discuss Michael Faraday's contribution to the invention of the transformer.
4. State why the transformer will not work on direct current systems.
5. Discuss transformer winding taps.

Lesson 7 Transformer Polarity/Connections

Introductory information:

Qualified Electrical Workers should have learned about transformer operation in regard to winding ratios as they affect voltage and current. Next, it is necessary to learn about another characteristic of AC transformers: polarity.

Transformer manufacturers perform extensive tests to ensure that a transformer nameplate shows the correct polarity. Keep in mind there are older transformers in the field, which may be either additive or subtractive polarity or may have a nameplate that is missing or damaged.

This topic may be brief but it is still vitally important. Knowing the polarity of a transformer will prevent damage to equipment and injury to personnel.

Remember: Transformer windings work both ways between primary and secondary windings. Ordinary transformers can either step-down or step-up voltage, depending on which side of the transformer voltage is applied. Polarity tests should only be performed after a careful review of the safety procedures involved.

As always, nothing takes the place of hands-on training. Foremen and Journeymen Electrical Workers are invaluable resources in all aspects of training, but especially in learning the importance of knowing the polarity of a transformer.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain safety procedures prior to paralleling single-phase transformers.
2. Describe the internal polarity of a single-phase transformer.
3. Diagram the proper way to set up equipment to check polarity on a single-phase transformer.
4. State industry standards as they apply to transformer polarity.

Lesson 8 Tap Changers and Tap Changer Operation

Introductory information:

When 2,400 volts was the average distribution primary voltage, transformers usually had taps to compensate for primary voltage drop. Due to the low primary voltage, almost every transformer was adjusted to meet a particular customer's need. This worked well for many years until demand grew and customers demanded power quality as well as quantity. To meet the demand, electrical systems have been converted so that 7,200 volts phase to ground and above are now common. Today, distribution transformers with taps are a rarity, as higher voltages and better voltage regulators, capacitors, and relays have met the demand for power quality.

There are still older transformers in the field with taps. For example, an engineer may order a new transformer with taps because of a customer's location, and every substation transformer is equipped with taps. Qualified Electrical Workers need to have an understanding of tap operation for the sake of their own safety and in case their company still uses tapped transformers.

The confusion that arises when dealing with taps is that most Qualified Electrical Workers assume that the lower the percentage of primary taps, the lower the secondary voltage will be. In fact, the closer the number of turns between the primary and the secondary, the higher the secondary voltage. If one has a 1:1 ratio, voltage in is equal to voltage out. So, when the primary windings are reduced from 100% to 95%, the secondary voltage is raised by 5% because the ratio between the windings is now closer.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain how a transformer's output voltage is changed using taps.
2. Describe the equipment needed to check load.
3. Demonstrate how to figure load on a single-phase transformer.

Lesson 9 Transformer: Completely Self-Protected

Introductory information:

Unfortunately, Qualified Electrical Workers continue to be seriously injured while working on CSP transformers because they have little or no experience working with a CSP. To better serve the customer and to keep themselves safe, all Qualified Electrical Workers should have a basic understanding of the CSP, as it remains a widely used piece of equipment. There is nothing inherently dangerous about a CSP that a little knowledge will address.

As with any piece of electrical equipment, the CSP should be worked on with safety in mind. The secondary breaker handle should be operated with a stick rated for the voltage and while the Qualified Electrical Worker is wearing rubber gloves.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the operation of the red warning light.
2. State the function of the internal primary fuse.
3. Describe the function of the secondary breaker.
4. Explain how to operate the secondary handle to get service back on.

Lesson 10 Installing Transformers

Introductory information:

One of the most common tasks assigned to a line crew is changing out or building new transformer stations. A quick check of the transformer prior to leaving the yard will avoid embarrassing situations such as hanging a 240/480-volt transformer when a 120/240-volt transformer was required. Knowing the employer's standards for building a transformer station is another aspect of the work one should strive to be an expert at. A transformer station built incorrectly can be dangerous to the Qualified Electrical Worker who has to troubleshoot it at a later date.

On-the-job training is fundamental to learning about transformer installations. Foremen and Qualified Journeymen Electrical Workers are always valuable resources in all aspects of training, but especially in correctly selecting, fusing, and installing transformers.

Learning Objectives:

After completing this lesson, you will be able to:

1. Draw secondary terminal connections for a single-phase transformer.
2. State the pre-installation checks to be performed prior to installing a transformer.
3. Describe bird-guard function as used on transformers.
4. Discuss transformer fusing as it relates to the protection of a transformer.

Lesson 11 Single-Phase Transformer Connections

Introductory information:

The single-phase transformer is not only the most commonly used transformer in the electrical industry, but is also the most versatile. It is important to the career of a Qualified Electrical Worker that he or she not only learn which wire goes where, but what is going on inside the transformer. The coils release the voltage they are designed for, and the arrangement of the leads on the secondary bushings allows one to utilize that voltage. Transformer coils can work while using very few wiring

diagrams. The reason fewer wiring diagrams are used is that many companies have their own way of making transformer connections. If Qualified Electrical Workers do not have a clear understanding of coil function, they might be at a loss when faced with wires coming out of secondary bushings in a fashion other than they may be used to.

Learning Objectives:

After completing this lesson, you will be able to:

1. Diagram three connections that can be made with a single-phase transformer.
2. Explain the difference between series and parallel coils.
3. Name safety checks to be made prior to paralleling transformers.

Lesson 12 Transformer Protection

Introductory information:

Knowing the way a system is coordinated related to transformer protection is essential for a Qualified Electrical Worker. Proper transformer fusing not only protects the transformer but also coordinates with tap fuses, which coordinate with all other system equipment. The various methods used to protect a transformer range from proper fusing to an awareness of how loading affects transformer capabilities. Knowing how a transformer operates and how to connect a transformer is useless unless the Qualified Electrical Worker knows how to protect it.

Although CSP transformers are seldom encountered by most Qualified Electrical Workers, they are extensively used by rural electric cooperatives, and may prove beneficial to Qualified Electrical Workers to know how a CSP protects itself.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the function of fuses as they relate to protecting a transformer.
2. Discuss underground transformer fuse protection.
3. Discuss the effects of transformer overheating.
4. Explain the effects of transformer loading on the operation of a transformer.

Lesson 13 Conducting Transformer Load Checks

Introductory information:

Understanding how transformers work is not only a safety issue, but can also save employers a lot of the money they spend on equipment, wages, and benefits. One reason so many transformers are brought into the warehouse is because many crews do not know how to troubleshoot a transformer station. They decide it is easier to change out a transformer than to take the time to pinpoint the problem. Unfortunately, the problem with the transformer remains after the change-out, and it is left for another crew or a troubleshooter to solve.

One skill that separates one Qualified Electrical Worker from another Qualified Electrical Worker is his or her ability as a craftsman to solve problems in the field. Knowing how to conduct transformer load checks will allow the worker and the engineer to make intelligent decisions and will distinguish them from the Electrical Workers who repair by replacing.

An apprentice should get into the habit of figuring load on every transformer he or she installs or troubleshoots. The method for checking a load is something Qualified Electrical Workers will use throughout their careers.

Learning Objectives:

After completing this lesson, you will be able to:

1. Determine the equipment needed to check load on a single-phase transformer.
2. Demonstrate how to figure load on a single-phase transformer.
3. Calculate the kilovolt-amperes being drawn from a single-phase transformer.

Lesson 14 Specific Hazards Working With Transformers

Introductory information:

A careful check prior to entering a work zone and knowledge of some of the dangers involved can eliminate injuries to Qualified Electrical Workers while working on transformers. A careful study of the hazards involved will provide some of the tools needed to stay safe while still doing a quality, craftsman-like job.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain safety procedures prior to working on transformers.
2. Describe how to avoid back-feed.
3. List several items to look for prior to energizing a transformer.

Lesson 15 Vectors

Introductory information:

Knowing how to draw a 3-phase bank using vectors (also called phasors in some parts of the industry) is an essential tool every Qualified Electrical Worker should have. The terms *wye* and *delta* and the combination of connections in which transformers can be arranged represent the banks Qualified Electrical Workers will be working with throughout their careers. With a firm understanding of vectors, one can use the vector drawings as a wiring diagram when troubleshooting a 3-phase bank.

Most apprentices draw a 3-phase bank using rectangles to represent transformers. With a good understanding of vectors, it will not be long before a simple statement such as, “wye-delta, corner grounded, 480 volt, 30° displacement” will provide a Qualified Electrical Worker with all the information needed to build the required bank.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the purpose of vectors as used in electrical drawings.
2. Figure the phase-to-phase voltage on a Wye connected bank.
3. Draw a vector diagram for a 3-phase bank connected wye-delta 0° displacement.

2nd Year - Level 3

Learning Objectives

Successful Qualified Electrical Workers must possess a strong knowledge of math. Level III opens with the student covering Working with Prefixes and Powers of 10, The Customary and Metric Systems of Measurements, The Circle, Area and Volume, and Measuring and Drawing Angles. It then transitions to blueprint fundamentals, electrical drawings and diagrams, and civil drawings. It closes with lessons on staking sheets and stakes and measuring and leveling devices.

Lesson 2-3-1 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. In order 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.

Review these points to successfully complete questions:

- 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.
- Answers for some problems might be needed to answer later questions.
- For all mathematical calculations, it is best to save rounding the answer to the last step of the calculation if at all. Rounding too soon may cause missed answers.
- When performing calculations that include the square root of three or the use of pi, use at least two decimal places. For example, $\sqrt{3} = 1.73$ or $\pi = 3.14$. Use of your calculator's π button is recommended.
-

Learning Objective:

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 2 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 end 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 3 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 4 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 5 Measuring and Drawing Angles

Introductory information:

Working with angles is a key part of turning plans and specifications on paper into something real. Learning how to draw and measure angles with a protractor is an invaluable skill. However, it is also invaluable to know how to calculate the size of an angle without the aid of a protractor.

Anyone who works in the building trades will find that they are often working with shapes and figures that are part of geometry. Therefore, a knowledge and understanding of geometry are essential to becoming a competent Qualified Electrical Worker. Understanding the concepts of angles is a key part of geometry and provides the foundation for understanding triangles.

Learning Objectives:

After completing this lesson, you will be able to:

1. Name and understand the different types of angles.
2. Measure and draw angles with a protractor.
3. Calculate the measure of angles without the use of a protractor.

Lesson 6 Right Triangles

Introductory information:

In a right triangle, there are special relationships among the angles and sides of the triangle. One of these relationships is stated in the Pythagorean Theorem, which shows the mathematical relationship between the hypotenuse (the side opposite the right angle) and the other two sides of a right triangle. This theorem has been used by mathematicians for thousands of years and is one of the most-used mathematical formulas in existence today.

The properties of triangles and the special attributes of right triangles will help significantly in the work of a Qualified Electrical Worker. The calculations involved allows one to determine lengths and angles without actually measuring them. Some applications that may require knowledge of triangles and specifically right triangles include conduit bending, power factor correction, and the theories involved with AC circuits. Therefore, it is very important to understand the basics of triangles and learn how to put them to work in day-to-day work activities. These concepts also provide the foundation of trigonometry, or triangle measurements.

Learning Objectives:

After completing this lesson, you will be able to:

1. Calculate the unknown lengths and angles of a right triangle.
2. Understand and use the Pythagorean Theorem.
3. Identify different types of triangles.

Lesson 7 Blueprint Lines

Introductory information:

The traditional method of making blueprints with a wet photograph process has been largely replaced with plotters and computer aided design (CAD) programs, but the word “blueprint” has been around for so many years that “blueprint” is used for any set of drawn specifications, regardless of how they are produced. It is important to know which symbols the electrical industry has adopted. Every Qualified Electrical Worker needs to know the basic set of lines used in the blueprints he or she will be working with.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the basic types of lines used on blueprints.
2. State the function of the basic lines used on blueprints.

Lesson 8 Introduction to Blueprints and Specifications

Introductory information:

Blueprints and specification sheets are documents that lay out every aspect of a job as the engineer wants it done. A Qualified Electrical Worker will need a firm understanding of the types of maps, drawings, and specification sheets that will be used throughout his or her career. Knowledge of the tools used by engineers to communicate with Qualified Electrical Workers is also useful.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the information contained in construction drawings.
2. Describe the information that would be found on a specification sheet.
3. List the types of drawings used in electrical construction.
4. State the primary uses of blueprints and specification sheets.

Lesson 9 Blueprint Fundamentals

Introductory information:

The word “blueprint” has come to mean any drawing used to communicate between the engineering department and the worker. As a Qualified Electrical Worker, knowing how to read and use blueprints and the information they contain will prevent costly delays and prevent mistakes. Regardless of the name given to them, blueprints require careful study prior to starting work and should be referred to during construction. They may be complicated, with multiple sheets or everything on one page, but all contain the information needed to complete the job.

Learning Objectives:

After completing this lesson, you will be able to:

1. Understand how and why blueprints are scaled.
2. Know the uses for a materials list and the types of information a materials list contains.
3. Know what type of information is found on each part of a typical blueprint.
4. Describe the main types of views found on a blueprint.

Lesson 10 Symbols, Conventions and Abbreviations

Introductory information:

The symbols, conventions and abbreviations form part of the language of electrical work that all Qualified Electrical Workers should know. This knowledge will also help them to communicate with fellow Qualified Electrical Workers. On-the-job training will provide the needed experience to become better acquainted with the language.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the purpose of symbols, conventions, and abbreviations used on blueprints.
2. Describe what various symbols, conventions, and abbreviations represent.
3. Explain what information is available on the various drawings discussed.
4. Describe the difference between standard and one-line electrical diagrams.

Lesson 11 Electrical Drawings and Diagrams

Introductory information:

The symbols that have been introduced previously will now start to come together. Electrical drawings in blueprints and specification books are the drawings that will be used the most. Keep in mind that all changes should be reported, and, as a Qualified Electrical Worker, be sure to make every effort to build it as called for. With time and on-the-job training, it will be second nature to look at a blueprint and visualize the entire circuit and pieces of equipment as they will appear in their final arrangements and relationships. Keep in mind that the engineer wants the system to look and perform in a certain way, and knowing how to read all symbols, conventions, and abbreviations is part of the job.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the symbols for transformer connections and associated electrical equipment.
2. List the types of drawings and diagrams used to illustrate an electrical system or circuit.
3. Describe what type of information is available in each kind of drawing and diagram discussed in this lesson.

Lesson 12 Civil Drawings

Introductory information:

This series of lessons deals with reading the instruments engineers use to convey their view of what a job should look like when it is completed. As Qualified Electrical Workers, be sure to learn how to

correctly interpret the information given. Civil engineering, the “grandfather” of all engineering practices, is introduced as an important point of study. Most prints used will not specify that a civil engineer drew part of it, but it is important to know how different engineering disciplines come together to provide the field information needed.

Learning Objectives:

After completing this lesson, you will be able to:

1. State three methods an engineer uses to provide additional information other than the drawings.
2. Find specific information on various civil engineering drawings.
3. Recognize and identify the maps used to place a structure.
4. Describe the difference between a note and a specification sheet.

Lesson 13 Reading Maps, Plans, and Profiles

Introductory information:

Direction arrows, units of measurement, and some lines go into map making. The plan and profile drawings may seem confusing, especially the information needed to place the line, but a careful study of the map will allow one to identify such things as pole size and span length. The plan and profile map and lesson questions will provide good practice in map reading.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss different maps used in building power lines.
2. Identify the items found on a print that are used to clarify the job.
3. Describe the methods used for measuring a job.

Lesson 14 Staking Sheets and Stakes

Introductory information:

As it has been for over one hundred years, and despite the advances of computers and global positioning instruments, every line must still be staked. The staking sheet may have various names from one part of the country to another, but it serves the same purpose everywhere, and will be the drawing most Qualified Electrical Workers will use throughout their careers. It is important to understand the different types and the purpose of stakes and staking sheets as well as the abbreviations and symbols used on them.

Field stakes are often moved or removed by passersby or earth moving equipment, and the staking sheet is to be considered the most accurate job record available. If the stake location does not match the sheet, the staking engineer should be consulted before proceeding. Entire jobs have been torn down and rebuilt because the jobs were built according to the stakes and not by the staking sheet. Therefore, it is essential for the Journeyman Electrical Worker to learn the symbols abbreviations that will become a part of his or her staking vocabulary.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify and know the function of different stakes.
2. List several items that are found on a staking sheet.

3. List the steps involved in laying out a transmission line.

Lesson 15 Introduction to Measuring and Leveling Devices

Introductory information:

Qualified Electrical Workers will be working with or around surveying equipment for the rest of their careers. Using surveying levels and transits requires formal training and hands-on practice, but learning about the instruments that lay out the blueprints on the ground is an important place to start.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the function of the various tools and equipment used in surveying.
2. Define the different types of measurements that are taken during a survey.
3. List the proper procedures to follow when setting up measuring instruments.

2nd Year – Level 4

Learning Objectives

Level IV opens with Introduction to Inductance and continues with lessons on Voltage Drop, Metering, Overvoltage Protection, Fault Indicator, Tower Footings, Tower Erection, Joining High-Line Conductors, and Sagging Conductors. The course also covers Dampers, Hold Down Weights, and Armor Rods, Phasing and Tying in Circuits, Overload Capabilities of Electrical Equipment, Phase Sequence, Back-feed, and Locating Faults and Restoring Service.

Lesson 1 Introduction to Inductance

Introductory information:

Note that alternating current behaves differently than direct current, and Qualified Electrical Workers need to know why. For example, a transformer with no load on the secondary draws some current in the primary. This is because of the inductance of the transformer coil.

It is important to understand inductance from the standpoint of its physical characteristics as well as how these characteristics affect electrical properties. This knowledge lays the groundwork for solving problems in AC circuits and understanding the operation of transformers and other inductive devices.

Learning Objectives:

After completing this lesson, you will be able to:

1. Understand the principles of electromagnetic induction.
2. Define inductance, self-inductance, and mutual induction.
3. Discuss the physical factors that affect inductance.

Lesson 2 Voltage Drop

Introductory information:

Customers who receive electrical energy must receive power at an acceptable voltage for their equipment. This is not as simple as it may seem, because every foot of wire and every piece of apparatus between the generating station and the customer represents a line loss or voltage drop. In order for one to comprehend how to compensate for voltage drop, voltage drop and its effects must first be understood.

Not all voltage drops are undesirable. A 120-volt drop across an incandescent lamp is necessary to heat the lamp to a temperature that causes light to be emitted; this is a useful voltage drop. However, if there is a five-volt drop caused by the wires leading to the lamp, the customer still pays for the five-volt drop but derives no benefit from it. Excessive voltage drops are undesirable because they are considered a loss and may be harmful if heat is produced and weakens the insulation.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the variety of conditions that can affect voltage drop.
2. Make calculations concerning line loss.
3. Discuss how wire size affects voltage drop.

Lesson 3 Metering

Introductory information:

Every worker in the electrical industry should have a basic knowledge of how a customer is billed and how metering equipment works. Improperly metering a customer may add or subtract substantially to his or her monthly bill and the power supplier will not be provided with an accurate representation of the load they are serving. It is important for Qualified Electrical Workers to understand metering, as some will encounter many types of metering equipment during their careers.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe and discuss operating characteristics of meters.
2. List three types of demand that are metered.
3. List two components used to correctly meter a load.

Lesson 2-4-4 Overvoltage Protection

Introductory information:

All Qualified Electrical Workers are in the business of keeping the lights on for as many customers as possible. Due to good engineering and hard work by Qualified Electrical Workers, most systems are currently in the +99% range of reliability. Engineers spend a lot of time designing and protecting their systems from overvoltages, and Qualified Electrical Workers need to know how this equipment operates and coordinates.

Getting a customer's lights back on as quickly and as safely as possible is the mark of a good Qualified Electrical Worker. Helping to maintain a coordinated system will allow others to see one's abilities as a Qualified Electrical Worker.

Learning Objectives;

After completing this lesson, you will be able to:

1. Describe how protective equipment operates.
2. Describe characteristics of faults and reasons for grounding.
3. State lightning behavior and purpose of lightning arrestors

Lesson 5 Fault Indicator

Introductory information:

Fault indicators (FCIs) are a valuable tool when troubleshooting a system, especially on underground. With proper placement and Qualified Electrical Workers, a system of FCIs will help to limit the size and duration of outages. For Qualified Electrical Workers, the job is to know how to use all equipment available to limit outages, including knowing how to interrogate substation equipment and interrupting field equipment signals. If a system of FCIs is in place, one of the jobs is to reset the devices after an outage, if they are the manual type.

While there are many types of FCIs and substation system-monitoring equipment, Qualified Electrical Workers should inquire into and become an expert at using the equipment at their respective companies.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe how equipment shortens outages.
2. List three ways FCIs operate.
3. State two factors that affect FCI operation.

Lesson 6 Tower Footings

Introductory information:

A transmission tower with an ability to withstand anything nature can throw at it is only as good as the foundation it stands on. Specialized crews or contractors are normally in charge of building foundations, and although it is rare for a Qualified Electrical Worker to be assigned to such a crew, every Qualified Electrical Worker should have a fundamental knowledge of tower construction and especially its foundation.

Learning Objectives:

After completing this lesson, you will be able to:

1. List three types of footing construction.
2. Describe poured concrete footing construction and requirements.
3. Describe proper grounding of steel towers.
4. Describe soil compaction requirements for tower footings.

Lesson 7 Tower Erection

Introductory information:

Most Qualified Electrical Workers at some time in their career will work on a transmission line crew. Although nothing can take the place of on-the-job training with a good crew, being knowledgeable of the process for erecting a steel tower can be quite beneficial.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe assembly procedures for handling of steel components.
2. List three work procedures used to protect the galvanized steel of a tower.
3. Describe wooden pole transmission structure types.

Lesson 8 Joining High-Line Conductors

Introductory information:

The same principles apply whether joining all conductors or high-line conductors. Qualified Electrical Workers have complete control when installing a splice on a house service or a transmission line. The results of that splice can be either the good service that customers expect or eventual failure. Nothing can take the place of on-the-job training with a good crew, but careful study and understanding of the different sleeves involved in joining transmission line conductors will be beneficial. In all cases, and especially when joining transmission line conductors, be sure to read and follow all manufacturer instructions.

Learning Objectives:

After completing this lesson, you will be able to:

1. State operations required in preparing conductors prior to applying sleeves.
2. Describe procedures for applying implosive sleeves.
3. State two items imprinted on a sleeve.

Lesson 9 Sagging Conductors

Introductory information:

Sagging conductors is one job every Qualified Electrical Worker will be involved with throughout his or her career. The conductors may be a triplex house service or a 750,000-volt transmission line. It may be tempting to disregard the methods explained and rely on the “eyeball” method. However, the “eyeball” method most often results in too tight a line, which can damage itself during heavy ice loading or temperature changes. The oldest reliable method is the use of sagging boards, but no matter what method is used, everyone on the crew should understand and practice sagging conductors.

When figuring the sag, a reading of air temperature and consulting a chart provided by the engineering department is usually all that is required. Be sure that the correct chart has been provided; the initial sag chart compensates for the non-elastic stretch of new wire. The final sag chart is used for new prestretched or re-used conductor. For example, a chart may read “#2ACSR 6/1 STR with a ruling span of 300 feet and an air temperature of 70°F.” A final sag chart shows 72 inches of sag, while the initial sag chart shows 58 inches of sag. Experience has shown that the “eyeball” method in the same situation would probably result in a sag of 36 inches or less.

For Qualified Electrical Workers, the primary responsibility is to provide the best service to customers. A well-built line with properly sagged conductors is evidence that it was built by true craftsmen.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss factors to consider when sagging conductors.
2. List charts and three methods used to sag conductors.
3. Describe how temperature changes affect the sag of a conductor.

Lesson 10 Dampers, Hold Down Weights, and Armor Rods

Introductory information:

Every wire vibrates because of wind across the conductor. That vibration can cause damage at the point of attachment, which may be a string of bells, a deadend, or a crossarm-mounted insulator. Several devices have been developed to absorb or counter conductor vibration. Armor rod, conductor weights, and damping devices are three of those devices. There are other devices, such as, spacer dampers, “Gallop Masters,” and spiral vibration dampers that workers will encounter in their career. Each type of equipment comes with complete manufacturer’s recommendations for application, which should be carefully studied.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe conductor vibration causes.
2. Discuss how armor rod is applied to a conductor.
3. List three remedies for countering conductor vibration.

Lesson 11 Phasing and Tying in Circuits

Introductory information:

Tying two circuits together may become necessary for several reasons, to include: storms, auto accidents, or to relieve load from a heavily loaded circuit. Knowing how to properly phase in circuits is a skill that will prevent the worker from starting a phase-to-phase fault, which is one of the most dangerous situations in the electrical industry. Phasing sticks are relatively easy to use. To avoid mistakes, always write down the phasing sequence as it is determined.

Voltage regulators should never be adjusted by Qualified Electrical Workers unless they are authorized to do so by their supervisors or engineers. Voltage regulators can contribute to a catastrophic failure if not handled properly.

All safety precautions, to include donning required PPE, should be taken when operating gang-operated switches or disconnects.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the function of and proper steps of using a phase tester.
2. List three reasons two circuits feeding off the same substation bus may not go together.
3. State three reasons voltage regulators must be accounted for before tying in circuits.

Lesson 12 Overload Capabilities of Electrical Equipment

Introductory information:

Knowing the overload capacity of all equipment, not just the transformers, can come in handy when troubleshooting customer problems. The same 15-kVA transformer can carry 125% of its rated capacity or 18.75 kVA for extended periods as long as the connected load allows for periods of cooling.

Learning Objectives:

After completing this lesson, you will be able to:

1. List three methods or circumstances that dispel heat from transformers.
2. Describe under what circumstances a transformer can be routinely overloaded.
3. State how the overload capacity built into electrical equipment can be used to the advantage of the company and the customer.

Lesson 13 Phase Sequence

Introductory information:

The phase sequence is the order in which the three voltages of a 3-phase system appear. Customer motors require a certain rotation of phases in order to operate properly. It is the job of the electric provider to ensure that proper rotation is maintained to the point of service. Disregarding or changing phase rotation can result in damage to the customer’s equipment.

Qualified Electrical Workers should be knowledgeable in how phase sequencing works and in how and when to use a rotation meter.

Learning Objectives:

After completing this lesson, you will be able to:

1. Demonstrate a general knowledge of phase sequencing by listing three of its characteristics.
2. State when it is necessary to check for phase rotation.
3. List three characteristics of phase rotation meters.

Lesson 14 Back-feed

Introductory information:

Back-feed is a condition where a conductor or piece of equipment is energized from the load side instead of the source side. A back-feed condition is far more common than most people think when making repairs on a downed power line. As common as a back-feed situation may be, being aware of the hazard and using safe work practices can prevent the situation from becoming a tragedy. Using live line methods, applying grounds, and checking for customers using generators during outages are three ways to deal with back-feed.

Learning Objectives:

After completing this lesson, you will be able to:

1. State the definition of back-feed.
2. List two situations where back-feed will happen.
3. State how to protect against back-feed.

Lesson 15 Locating Faults and Restoring Service

Introductory information:

Knowing how to troubleshoot overhead and underground faults is essential to all Qualified Electrical Workers. Always follow the company's procedures when locating faults. Knowing general guidelines as well as the system and equipment will be helpful when troubleshooting faults.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the operation of protective equipment.
2. List two types of fault locating equipment for both overhead and underground.
3. State two safety procedures concerning the use of fault finding equipment.
4. State conditions that may be found when patrolling an overhead line for a fault.

2nd Year – Level 5

Learning Objectives

Cabling splicing is the main focus of Level V. Topics covered include safety, materials and tools, preparation, terminations, elbows, grounding cables, pulling, insulation testing, and manufacturers' kits. Students will learn how to use a megohmmeter and gain experience in cable fault locating, underground troubleshooting, and confined spaces.

Lesson 1 Introduction to Medium Voltage Cable Power Cable

Introductory information:

What is cable splicing, and what are the duties of a medium voltage cable splicer? The definition of *cable splicing* is the manufacturing of cable in the field under adverse conditions without the use of modern manufacturing equipment or quality control testing. The job of a medium voltage cable splicer is much more involved than just reconstructing cables. The splicer must understand the different steps involved in cable manufacturing, have an awareness of the different types of conductors and their uses, understand how the environment will affect the cable that is being installed or repaired, and have a keen understanding of proper safety techniques and practices. The splicer must be able to perform the proper testing procedures on the cable and medium voltage equipment being used. Clearly, the job tasks for a cable splicer are many and the understanding needed to perform the job satisfactorily is great. It is beneficial to the worker to have knowledge of the types of cables used with medium voltage installations, the different insulations used on medium voltage cables, and some of the terminology used in cable splicing and medium voltage installations.

Learning Objectives:

After completing this lesson, you will be able to:

1. Describe the range of medium voltage.
2. Describe what cable splicing is.
3. Explain how various environmental conditions adversely affect the performance of electrical insulation.
4. Explain the benefit of shielded insulation.
5. Explain the difference between a 100% and 133% level of insulation.

Lesson 2 Cable Splicing I – Safety

Introductory information:

The subject of safety should be very important to every Qualified Electrical Worker. Cable splicing takes safety concerns to a higher level due to the higher voltages involved. As there are many aspects to the subject of safety, a thorough review of reference materials will provide additional information. Every cable splicing job must start with a briefing at the job site, as required by federal law. The jobsite should be prepared according to standard procedures, and the Qualified Electrical Worker must wear the appropriate protective clothing. Hard hats and eye protection should be considered part of a Qualified Electrical Workers' normal work attire. Rubber gloves should be used when working with live-line tools for such jobs as making and breaking a loadbreak elbow connection. If a splice or elbow is to be installed in a manhole or vault, OSHA safety rules for enclosed or confined spaces will apply. The general entry procedures should include four separate aspects: (1) testing, (2) ventilation, (3) a minimum of two workers with continuous communication, and (4) cleaning.

When installing a termination from an aerial bucket, a safety harness (fall arrest system) must be worn. Qualified Electrical Workers should be aware of bucket rescue procedures as well as applicable safety practices when making an aerial installation from a ladder or scaffold.

When set-up preliminaries are completed, the deenergized state of the cable must be confirmed. Lockout/tagout procedures must be understood and followed.

Preparation of the cables and installation of the splices and terminations or elbows will require working with various tools. Care must be taken when using cutting tools, crimping tools, and when working with sharp edged shielding, drain wires, and so forth. By following established procedures and rules, being careful, and using common sense, cable splicing can be a safe and rewarding job.

Learning Objectives:

After completing this lesson, you will be able to:

1. Define electrical job safety.
2. Understand what is involved in cable splicing safety procedures.
3. Understand the basic steps for preparing to work underground in a manhole or aerially in a bucket.
4. Work safely around medium and high voltages.

Lesson 3 Cable Splicing II – Material and Tools

Introductory information:

An important factor in cable splicing and terminating is understanding how the cable is constructed. There are different types of materials used in the construction of medium voltage cable and cable splicing, and Qualified Electrical Workers will typically encounter different types of conductors in the field.

Many of the tools and materials used in the field by Qualified Electrical Workers will also be used when making a splice or termination. There are several tools that can be used, such as a splicer, which may be new to some workers.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the different types of material used in making a medium voltage splice or termination.
2. Discuss the different types of tapes used in making a splice or termination.
3. List the tools used in making a medium voltage splice or termination.
4. Identify the different types of stranded conductors used in medium voltage cable.

Lesson 4 Cable Splicing III – Cable Preparation

Introductory information:

Failure of cable accessories is one of the most common causes of underground electrical system outages. There have been many studies made of such failures, with most concluding that the majority of failures occurred due to poor workmanship performed during cable preparation. However, most well-trained, experienced installers work for an entire career without any failures being attributed to their work. Cable accessories, both traditional and contemporary, require installation by skilled craftsmen trained in the theory and practice of installing splices, terminations, and elbows.

An analysis of failures reveals that most of the workmanship failures involve the use of cutting tools, such as knives, scoring tools, and stripping tools. The cause of failure usually related to cuts that

were made too deep into the underlying layer, which forms an air void, resulting in corona discharges and, ultimately, failure. Along with being a trained and skilled worker, a key to good cable preparation is the proper use of sharp, high quality tools. These tools include traditional hand tools, as well as specialized, mechanical, cable preparation tools.

Cables are prepared by carefully removing the jacketing, shielding, and insulation layers in cutback steps. The removal starts on the outside diameter with the jacket, and steps down through the layers to the conductor. The dimensions for these cubacks can be critical. The student must become familiar with calculating the correct dimensions from the manufacturer's instruction sheet and accurately executing them on the cable. Once the cable is prepared, it must be properly cleaned before the accessory is installed. Special cable preparation solvents are available for cleaning the cable insulation. In some cases, an abrasive may be necessary. A non-conductive, electrical grade abrasive is then used before cleaning with solvent.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify the workmanship causes of cable accessory failures.
2. Describe cable preparation steps, starting with the jacket and ending with the conductor.
3. Select and use the proper traditional hand tool or special mechanical cable preparation tool.
4. Understand the critical importance that cable preparation plays in cable accessory installations.

Lesson 5 Cable Splicing IV – Terminations

Introductory information:

If cable runs did not have ends, terminations would not be necessary. All cable runs have two ends (more if the cables contain tap splices, such as a tee splice), each requiring a termination.

A cable termination performs two functions: (1) provides an end to the cable conductor, the insulation, and the grounded insulation shielding, and (2) provides an appropriate means of connecting the cable to the electrical apparatus, overhead line, etc.

A termination differs from a splice in that it discontinues the cable's insulation shield, while a splice continues the shielding across the splice, from cable to cable.

The key to building a proper termination is in the understanding of where the electrical stress will be when the shielding is removed. By applying stress control at the voltage stress area, stress concentration can be reduced and the possibility of an electrical failure will be decreased considerably.

Learning Objectives:

After completing this lesson, you will be able to:

1. Distinguish between low-voltage and high-voltage terminations.
2. Identify the important parts of a termination.
3. Identify the best lug application for a termination.
4. List the atmospheric considerations when building a termination.

Lesson 6 Cable Splicing V – Splicing

Introductory information:

A splice can be defined as two or more conductors joined with a suitable connector, re-insulated, re-shielded, and re-jacketed with compatible materials applied to a properly prepared surface. This basically translates to the rebuilding of a short section of cable.

There are several common types of splices available today, such as hand-wrapped tapes, pre-molded push-on, heat shrink, cold shrink, 600-ampere elbows, and three-conductor splices. The splicing product should be selected based on matching the cable (type, size, voltage rating, etc.). Regardless of the selection, there are five basic steps involved in building a splice.

1. Prepare cables
2. Join conductors with connector(s)
3. Re-insulate
4. Re-shield
5. Re-jacket

Good cable preparation, paying close attention to the dimensions, and following the manufacturer's instructions are critical. Good workmanship is the key to a reliable medium or high voltage splice installation.

Learning Objectives:

After completing this lesson, you will be able to:

1. Understand the importance of good cable preparation.
2. Discuss all of the functions of a splice as they relate to the functions of cables.
3. Select a splice kit to match the cables being joined.
4. Calculate cable preparation dimensions from a manufacturer's instructions.

Lesson 7 Cable Splicing VI - Elbows (Separable Connectors)

Introductory information:

The elbow is often referred to as the erector set of cable accessories. It can be used in a variety of applications and configurations, such as dead-front terminating, splicing, switching, sectionalizing, live dead-ending, and branching. Elbows are available in two general categories: 200-ampere and 600-ampere. The 200-ampere elbow is designed for distribution class cables, while the 600-ampere elbow is for feeder cables. The 200-ampere and 600-ampere names indicate the maximum continuous current rating of the elbow.

The 200-ampere elbows come in two configurations: loadbreak and deadbreak. These elbows have different operating interfaces and are not compatible with each other. The loadbreak elbow is the most common and can be operated in both loadbreak and deadbreak modes. By contrast, 600-ampere elbows are operated in a dead-break only. The standard live-line tool for operating elbows is referred to as a "shotgun stick."

It is very difficult to determine if a dead-front connection is deenergized. Elbows are available with an optional test point, which has a capacitive coupling with the elbow's conductor. After de-energizing and removing the cap, a special high impedance voltage sensor can be used to check voltage status. Any voltage reading would indicate that the elbow connection is not ready to operate, and further investigation is necessary.

Selection of elbow products is made in accordance with the equipment it is to be connected to. Dead-front switchgear and transformers are available with 200-ampere or 600-ampere bushings to match the appropriate elbows. Installing an elbow onto the cable is very similar to that of a push-on molded rubber splice or termination. Properly installed, elbows have proven to be very reliable.

Learning Objectives:

After completing this lesson, you will be able to:

1. Understand the terminology used with elbow products.
2. Select between 200-ampere and 600-ampere elbows.
3. Distinguish between deadbreak and loadbreak installations.
4. Operate (make or break) an elbow connection using a shotgun stick.
5. Describe proper kit assembly procedures used for installing an elbow.

Lesson 8 Cable Splicing VII – Grounding Cables

Introductory information:

There are many aspects to the subject of grounding. A ground establishes a common reference for the system voltage, and provides safety for personnel and a return path for fault currents, switching surges, lightning surges, etc. However, there is one fact that stands out when it comes to installing a medium or high voltage shielded power cable: the cable's metallic shield MUST be grounded for safety and operation.

Because of their shared installation locations, splice, termination, and elbow kits are usually used for making the cable ground connections. The accessory-to-cable shield connections were traditionally soldered in the field. Today, most of the manufacturers' kits contain solderless connectors, the most common being the constant force spring. Kits usually include a ground braid sized to fit the job.

Grounding is a very important part of a cable and cable accessory installation. It is mandatory to ground the cable. Safety and the dissipation of voltage surges are improved through proper grounding.

Learning Objectives:

After completing this lesson, you will be able to:

1. Understand the importance of grounding a shielded power cable.
2. Explain the advantages and disadvantages of single-point grounding, double-end grounding, shield breaks, cross bonding, quarter mile grounding, and concentric neutral grounding.
3. Make a decision for selecting a grounding method for a specified job vs. a non-specified job.
4. Install a cable ground using a constant force spring and ground braid.
5. Connect a concentric neutral cable to ground and to a pre-molded accessory grounding tab.

Lesson 9 Cable Splicing VIII – Pulling Cables

Introductory information:

Pulling cable into a manhole or a piece of switchgear requires that many factors be considered before the first cable can be pulled. Proper planning and the use of the "right equipment for the job" will save time, money, and energy. Damaging a cable that is being pulled through conduit into a piece of equipment or manhole can be a very costly mistake. Care and planning before, during, and after the installation of all underground cable projects can make the installation of the cable a smooth, efficient, and safe operation.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify precautions that should be observed before starting any cable-pulling job.

2. Calculate cable pulling tension weights.
3. List safety factors that should be followed when pulling cable into a duct.
4. Discuss how to set up the cable reels and pulling equipment for any cable pull.
5. Identify the hazards associated with pulling cable.
6. Discuss different methods used for installing pull strings and pull ropes.

Lesson 10 Test Instruments - How to Use a Megohmmeter

Introductory information:

The megohmmeter has many uses and comes in a variety of sizes. The instrument is used to test insulation on electrical equipment, from motors to underground primary cable. Follow all manufacturers' safety and operating instructions for the meter being used.

Learning Objectives:

After completing this lesson, you will be able to:

1. State three reasons for performing a megohmmeter test.
2. Describe the proper hookup and use of a megohmmeter when testing a single cable.
3. State two safety precautions that should be taken when doing a megohmmeter test.
4. State the formula used to determine insulation resistance.

Lesson 11 Cable Splicing IX - Insulation Testing

Introductory information:

In many parts of the country, underground cables that were designed for a service life of 30 years have surpassed that life by decades. Knowing the condition of the insulation protecting the cable allows its owner to do preventative maintenance and accounts for the cable's extended life. Qualified Electrical Workers must be aware of the conditions that deteriorate insulation and the tests that are performed to find trouble spots before a catastrophic cable failure occurs.

Learning Objectives:

After completing this lesson, you will be able to:

1. State two purposes of cable testing.
2. State the three types of cable tests most commonly performed.
3. List three conditions that affect a cable's condition.

Lesson 12 Cable Splicing X – Introduction to Cable Fault Locating

Introductory information:

Knowing how to quickly and safely locate underground faults is an essential skill for every Qualified Electrical Worker. The most common piece of equipment in use for finding residential faults is the thumper method. Remember, all safety and operating manuals particular to the equipment being used should always be studied carefully and all procedures followed.

Learning Objectives:

After completing this lesson, you will be able to:

1. State three safety precautions that must be followed when a thumper is used to locate a cable.
2. Describe the procedure to follow when using a thumper to surge a cable.
3. List two conditions that may exist that will not allow a thumper to locate a fault.

Lesson 13 Cable Splicing XI - Underground Troubleshooting

Introductory information:

Knowing how to troubleshoot an underground system ensures that customers are brought back online quickly and safely. There are many procedures used to troubleshoot an underground system, but it is equally important to be familiar with and to follow local procedures.

Learning Objectives:

After completing this lesson, you will be able to:

1. List three reasons cable may fault other than lightning or traffic accidents.
2. State the one thing that a Qualified Electrical Worker has control over to prevent cable failure.
3. State the procedure for using a grounding spike.
4. List three things to look for when doing a piece-by-piece system inspection.

Lesson 14 Confined Spaces

Introductory information:

A confined space is considered by OSHA and other agencies to be one of the most dangerous places for workers to enter. In a confined space, if the air is bad, a worker is only one breath away from unconsciousness and possible death. All OSHA and local safety procedures should always be followed when entering a confined space.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss the procedures for proper ventilation of a confined space.
2. State the four atmospheres to check for in a confined space.
3. Describe the training OSHA requires for confined/enclosed spaces.
4. Describe the difference between an enclosed space and a confined space.

Lesson 15 Cable Splicing XII – Manufacturers' Kits

Introductory information:

The majority of splicing and termination jobs today are performed using manufactured kits. Cable accessory manufacturers generally design kits around modern methods for handling the functions of a splice, termination, or elbow (separable connector). These factory kits are usually much faster and easier to install than traditional methods, such as hand-applied taping. The speed and ease comes at a cost, however, as the kits are generally quite sensitive to proper selection, cut-back dimensions, and unique installation steps. Although kits appear easy to install, skill and training remain necessary for making a reliable installation.

IEEE standards are considered the industry standard for splices, terminations, and elbows. The standards establish the electrical ratings, test requirements, product classifications, etc. of medium

and high voltage cable accessories. Most manufactured kits are designed to meet or exceed these standards. Compliance is an assurance that the accessory will not be a weak link in a shielded cable system.

Detailed cable information is necessary for providing the electrical worker information necessary for selecting the proper kit. This information is readily available on new jobs, but may not be for retroactive jobs. The installer must also have knowledge of the application and environment. The kit selection may not include all of the necessary components, such as connector(s), shield adapter, jacketing, etc., which must then be ordered separately. After verifying the correct kit and accessories are on the jobsite, along with proper tools, the installation can proceed. The key to a quality kit installation is to carefully follow the manufacturer's instructions.

Learning Objectives:

After completing this lesson, you will be able to:

1. Define the importance of training and craftsmanship required for installing manufactured kits.
2. List the IEEE standards that apply to splice, termination, and elbow kits.
3. Identify the different types of manufacturers' kits.
4. Select a proper kit based on cable, application, and environmental information.
5. Follow a manufacturer's kit instructions.

2nd Year – Level 6

Learning Objectives

Crane and traffic signal practices are covered in the course. Crane topics include mobile cranes, boom capacities and load charts, rigging vectors, and lifting and digging operations. After gaining an overview of the traffic signal industry, students will focus on flagging, signs, and barricades, traffic control devices, hardware, and equipment. The course closes with lessons on caissons, basic signal blueprints, cabinets, and phasing and traffic flow.

Lesson 1 Mobile Cranes

Introductory information:

Qualified Electrical Workers should always ensure the safe operation of equipment that they will be using throughout their careers, such as mobile cranes, aerial devices, and digger derricks. Every Qualified Electrical Worker needs to know how to properly inspect equipment; a pre-trip inspection ensures that the equipment is performing as it should, and thereby helps to secure worker safety.

Although classroom experience is helpful, nothing takes the place of hands-on training. A Qualified Electrical Worker may not be the driver or operator of equipment, but he or she should still get into the habit of inspecting equipment prior to its use and become familiar with state and federal Department of Transportation (DOT) rules and regulations as well as the company's operating requirements.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss safety procedures to keep from damaging equipment.
2. Explain how to stabilize a truck before using a boom.
3. Identify DOT requirements for truck operators.
4. Discuss truck grounding.
5. Explain how to monitor the hydraulic system for troubles.

Lesson 2 Boom Capacities and Load Charts

Introductory information:

The introduction of fiberglass booms into electrical line work has revolutionized the industry. Because fiberglass is lighter than steel and has insulating properties, bucket trucks and digger derricks can reach higher, faster, and safer than a steel boom. However, despite the modern boom's enormous power, it is not indestructible. Mandatory maintenance, inspection programs, and operator training must all be in place.

Every Qualified Electrical Worker needs to be familiar with and know how to use the capacity charts as posted on equipment to ensure that every lift is a safe one. Get into the habit of consulting the load charts and calculating every lift prior to making it.

Learning Objectives:

After completing this lesson, you will be able to:

1. Use the load charts to calculate a safe lift for a given weight.
2. Discuss the set-up procedures for a truck with a mounted boom.
3. Discuss how a truck may tip over with little or no weight at the boom tip.

4. Understand the procedures for the safe operation of booms.

Lesson 3 Practical Applications – Rigging – Vectors

Introductory information:

Rigging for a proper lift is an essential part of being a Qualified Electrical Worker. When setting a transmission tower or sending up a line hose, crossarm, or transformer, proper rigging will make everyone's job easier.

Practicing knot-tying and taking advantage of other Qualified Electrical Workers' and Foremen's experience on matters of rigging will make every lift a safe and efficient one. Knowing how to figure the working load limit of blocks and ropes is also an essential aspect of rigging. When rigging, use the best equipment available. Using undersized or worn equipment might result in injury and will result in equipment damage.

Learning Objectives:

After completing this lesson, you will be able to:

1. Explain rope, chain, hardware, and sling characteristics.
2. Discuss blocks and the effect of overloading on blocks.
3. Describe angle effects on conductors and rigging.

Lesson 4 Lifting and Digging Operations

Introductory information:

Digging to set poles is one of the most common jobs performed by Qualified Electrical Workers. Diggers are powerful machines, but they are not indestructible. It is up to the operator to use diggers in a safe and proper manner and to perform daily inspections as called for by OSHA and the Department of Transportation (DOT).

Apprentices should take advantage of every opportunity to practice with the equipment being used in the field. Apprentices should only operate the equipment while under the direct supervision of a Qualified Journeyman or Foreman. Never practice near energized lines or equipment until qualified to do so.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss proper procedures and operating methods for equipment use.
2. Discuss operational methods that might damage a digger.
3. State three requirements of OSHA 1910.269(p) concerning mechanical equipment.
4. Calculate the depth of a hole needed for various pole sizes.
5. Calculate the WLL of wire rope.

Lesson 5 Traffic Signal Industry Overview

Introductory information:

The electrical profession often expands beyond traffic signal construction and into other areas such as maintenance, sales, or management roles. Knowledge and training throughout the apprenticeship process will open doors of opportunity for the future.

Learning Objectives:

After completing this lesson, you will be able to:

1. List the different types of work done by a Qualified Electrical Worker.
2. Identify the basic components of a traffic signal system.
3. Better understand the world of a Qualified Electrical Worker.
4. Discuss job site concerns with respect to safety.
5. List the basic steps for installing a traffic signal.

Lesson 6 Flagging, Signs, and Barricades – Part I

Introductory information:

When working in construction, there are times when it may be necessary to reroute vehicle traffic from the work area. Those workers in the area from which the traffic is being rerouted cannot always rely on the posted signs or mechanical warning devices to alert the traffic of the upcoming construction. The trained flagger becomes the key to establishing a proper and safe work zone for both the workers and the motorists.

When working as a flagger, protecting one's self, one's fellow workers, and the public are the most important parts of the job. The flagger also needs to understand that because of his or her presence and visibility, he or she becomes the public relations person for both the contractor and the municipality overseeing the work.

A large number of workers are injured by vehicular traffic each year. Many members of the public are also injured as a result of employees working in public places. Good judgment and proper warning devices can minimize injury to both workers and the public. Be alert, stay alive, and help others to do the same.

Learning Objectives:

After completing this lesson, you will be able to:

1. Discuss the Flagger's Rules of Conduct.
2. Dress properly when working as a flagger.
3. Identify the responsibilities associated with the duties of a flagger.
4. List the hazards that a flagger may be exposed to on the job.
5. Discuss how the weather affects the job of a flagger.

Lesson 7 Flagging, Signs, and Barricades – Part II

Introductory information:

Three paramount concerns for anyone studying flagging are the safety of the flagger in and around the work zone, the motorists' safety in that work zone, and the flagging signals used by the flagger.

Safety for the flagger in the work zone is a critical concern. An average of 40,000 injuries occurs each year due to highway work zone related crashes. Fatalities from these crashes have risen 26% since 1997.

As work zone accidents continue to increase due to vehicular traffic, the safety of motorists also becomes a greater concern. Many motorists find construction zone detours confusing to navigate. Many are driving in unfamiliar conditions as well as unknown areas.

A flagger's job is to safely control activity in and around the work zone. Controlling traffic is accomplished by communicating the necessary messages and signals to the motorist. Simple hand signals and devices are used for this purpose.

Learning Objectives:

After completing this lesson, you will be able to:

1. Be safely positioned in a work zone.
2. Guide motorists up to and through a work zone.
3. Understand and use hand signals and other traffic control devices.
4. Understand and use the three-second rule for controlling following distance.
5. Describe how weather, road conditions, and reaction time can affect stopping distance.

Lesson 8 Flagging, Signs, and Barricades – Part III

Introductory information:

Traffic control in a construction zone is made safer for motorists due in part to standardized traffic control devices and practices across the country. The *Manual on Uniform Traffic Control Devices (MUTCD)* is the basis for traffic control devices. Flaggers should know how and where these devices are used. The flagger should also be familiar with the types of channelization devices as well as their use in a traffic control zone. Setting up a traffic control zone is an integral part of traffic control. The four parts of a traffic control zone must be understood, and the flagger must understand his or her responsibilities within them. The placement of the flagger in the work zone is vital to ensuring his or her safety.

Learning Objectives:

After completing this lesson, you will be able to:

1. Know and explain the function of the four parts of a traffic control zone.
2. Identify and know the purpose of different signs used in a traffic control zone and where to place them.
3. Identify the various types of channelizing devices and their correct placement in the work zone.
4. Understand the different types of tapers used in a work zone and how to set them up.

Lesson 9 Flagging, Signs, and Barricades – Part IV

Introductory information:

Flaggers should be familiar with special flagging conditions, such as nighttime, freeway, and utility flagging; surveying; and emergency response. Each of these situations requires special considerations with respect to equipment, conditions, and safety.

Learning Objectives:

After completing this lesson, you will be able to:

1. Understand traffic control safety measures at night.
2. Be aware of special considerations for flagging on freeways, at intersections, and during emergencies.
3. Use warning lights and arrow displays for traffic control.
4. Set-up traffic control for short duration work.

Lesson 10 Introduction to the Manual on Uniform Traffic Control Devices

Introductory information:

n the late 1920s and early 1930s, the need for standardized traffic control on streets in the public right-of-way became obvious. As a result, the first *Manual on Uniform Traffic Control Devices*, also known as the "*MUTCD*," was published in 1935.

Learning Objectives:

After completing this lesson, you will be able to:

1. Understand the purpose of the *MUTCD*.
2. Locate information and definitions in the *MUTCD*.

Lesson 11 Traffic Signal Hardware and Equipment

Introductory information:

Functioning as a Qualified Electrical Worker requires an in-depth knowledge of traffic signal hardware and equipment. It may be necessary to understand how traffic hardware is assembled and the purpose of each piece of hardware. Many pieces of signal hardware and equipment may be used in any type of intersection construction, while some pieces of equipment have a specific use in only one type of intersection. Intersections are classified by the type of mounting that is used to hang the overhead signal heads. Qualified Electrical Workers can benefit from learning about mastarm and spanwire intersections.

Learning Objectives:

After completing this lesson, you will be able to:

1. Identify and understand the makeup of a traffic signal head and a pedestrian signal head.
2. Understand pedestrian push-button applications.
3. Learn mastarm applications and hardware principles.
4. Learn span wire applications and hardware principles.

Lesson 12 Underground Installations – Caissons

Introductory information:

Caisson construction is one of the most vital aspects of building a traffic signal. The caisson must be built to an engineer's specifications due to the load of the pole and mastarm on the caisson once installed. The proper dimension of the hole and the soil conditions in which the caisson is to be placed are the first concerns. Poor soil conditions mean a sturdier base must be constructed. A properly tied rebar cage ensures the structural integrity of the caisson. Aiming the anchor bolts is perhaps the most vital part of caisson construction. Poorly aimed anchor bolts will result in a poorly aimed mastarm and a sloppy looking intersection. Each part of caisson construction is important, as repairing a mistake is a major expense and delay. Repairing a caisson is seldom an option for structural reasons. In many cases, replacement is the only (and most expensive) option.

Learning Objectives;

After completing this lesson, you will be able to:

1. Understand the construction of a caisson.
2. Know how to aim anchor bolts.
3. Understand intersection layout and mastarm orientation.
4. Know how a rebar cage is constructed.
5. Know when a sono tube is needed and how to use it.

Lesson 13 Introduction to Basic Signal Blueprints

Introductory information:

Traffic signal plans are essential to the installation of any traffic signal. The plans represent the signal job that is released for bid from the owner. The plans are designed by a traffic engineer, bid on by contractors, and built by a traffic signal construction crew. Every aspect of a traffic signal installation revolves around the plans.

Learning Objective:

After completing this lesson, you will be able to:

1. Understand the different pages of a plan set and what information each page contains.
2. Read and understand the importance of plan notes.
3. Identify traffic signal symbols used in plan sets.
4. Know the different scales found on a construction drawing and how to use them.

Lesson 14 Introduction to Traffic Signal Cabinets and Equipment

Introductory information:

To fully understand how an industry got to where it is, it is important to understand its history. An introduction to the history of traffic signals, traffic signal equipment, and traffic signal industry standards that were developed as a result of this history is a good place to start.

Learning Objectives:

After completing this lesson, you will be able to:

1. Know the history of traffic signals.
2. Understand how the electro-mechanical controller operates.
3. Understand the purpose of NEMA specifications and the 170 program.
4. Identify traffic signal cabinet components and have an understanding of their operation.
5. Understand the concept of electrical inputs and outputs.

Lesson 15 Phasing and Traffic Flow

Introductory information:

The future of a Traffic Signal Technician depends on his or her understanding of traffic flows and vehicle phasing. Everything about the operation of a traffic signal revolves around the phasing of that intersection. There are defined protocols that dictate how vehicles and pedestrians move safely through an intersection. Every Traffic Signal Technician should be familiar with the operation of a

traffic signal controller, phase assignments to vehicle movements, and the ring diagram. Everything about the safety and sequencing of the signals relates to the ring diagram.

Learning Objectives:

After completing this lesson, you will be able to:

1. Understand the ring diagram.
2. Know how to properly phase an intersection.
3. Identify compatible vehicle and pedestrian movements.