

## **SUBSTATION ELECTRICIAN**

	<b><u>Hours</u></b>
<b><u>Maintenance Total:</u></b>	<b><u>3180</u></b>
Equipment testing and setup	500
Power transformer Work	800
Tapchanger work	430
Transmission Circuit Breakers	550
Distribution Circuit Breakers	500
Troubleshooting/Prints/Analysis	250
Capacitor Banks	150
 <b><u>Construction Total:</u></b>	 <b><u>3150</u></b>
Grounding	550
Steel work/substation structures	550
Equipment Setting/Conduit Install	550
Sta. Svc. Equip/Wiring/Install	650
PT,CT,CCVT Connections/Wiring	800
Bucket/Motorized Equip operator	50
 <b><u>Shop Total:</u></b>	 <b><u>200</u></b>
General Shop	200
 <b><u>General:</u></b>	 <b><u>1470</u></b>
Safety	480
Switching	260
Classroom and associated study	730

**TOTAL PROGRAM HOURS – 8000**

# LESSONS FOR APPRENTICE STUDY AND ASSOCIATED HOURS

\*The first 3 years follows the Pro Tech LMS. Each year is broken up into 6 levels, allowing for 1 level every 2 months, 3 levels per step. The additional classroom activities are listed on a monthly basis, one halfway through each level, and one at the end of each level (All viewed in this font). The fourth year (7<sup>th</sup> and 8<sup>th</sup> step) will be post completion of the Pro Tech LMS followed curriculum, and will detail the remaining lessons and activities leading up to completion of apprenticeship, to culminate in a series of final (Top Out) tests.\*

## 1<sup>st</sup> Six Months (Step 1)

### ProTech Skills Year One: Level One

Materials: Web resources and courseware

This course begins with a lesson that instructs the student on how to study the course and gives helpful pointers on negotiating the course materials. The next three lessons present the advantages of an IBEW/NECA apprenticeship and the responsibilities of an apprentice. Other lessons give the student a thorough understanding of the history of the IBEW and NECA. This course also covers subjects that every apprentice should be familiar with, such as avoiding the hazards of drug use, sexual harassment, absenteeism, and how to achieve a sense of professional personal conduct.

#### ProTech Skills Level One – Lesson One: How to Study This Course and Achieve Your Personal Goals 2 Hours

- Utilizing Web resources and added courseware, apprentice will learn to demonstrate a positive attitude toward related training throughout the apprenticeship by completing all assignments and participating in classroom activities, as well as develop and demonstrate good study habits by being prepared for class and asking pertinent questions related to the lesson.

#### ProTech Skills Level One – Lesson Two: Knowing Your Apprenticeship and Your Responsibilities 2 Hours

- Apprentice will learn to demonstrate an understanding of the terms and conditions of the Apprenticeship Agreement through classroom discussion.

#### ProTech Skills Level One – Lesson Three: The Attributes of an IBEW/NECA Apprenticeship 2 Hours

- Apprentice will list the qualities that identify a competent, qualified Journeyman Electrical Worker, list the quality characteristics the JATC seeks in an applicant for apprenticeship, and state the primary purpose for which apprenticeship exists.

## ProTech Skills Level One – Lesson Four: Your Job and the Future it Holds for You

**2 Hours**

- Apprentice will list the costs of doing business, explain why management is interested in training, and list the qualities an IBEW-NECA Journeyman must have.

## ProTech Skills Level One – Lesson Five: Sexual Harassment

**2 Hours**

- Apprentice will define sexual harassment in the workplace, list factors that are considered by the courts in sexual harassment cases, identify sexual harassment activity, explain the possible repercussions of participating in harassing activity, and how to react appropriately to situations involving sexual harassment.

## ProTech Skills Level One – Lesson Six: The IBEW and its History

**2 Hours**

- Apprentice will gain knowledge about the IBEW and its contributions in dignifying the lifestyle of all Electrical Workers, develop a positive attitude toward the industry and contribute to its cause, display an appreciation for what the IBEW has to offer its members, and learn the history of the IBEW.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Tour of training substation and live substation. Issue and go over apprentice cards, Supplemental Agreement, expectations, access to Pro Tech LMS, and tools issued. Intro to beginning print numbers (E1s, E10s-E14s), disconnect numbering, PCB numbering, and cable numbering. Beginner single line reading.\***

## ProTech Skills Level One – Lesson Seven: NECA's Structure and Heritage

**2 Hours**

- Apprentice learn a basic knowledge of the NECA's history and structure.

## ProTech Skills Level One – Lesson Eight: Avoiding the Hazards of Drug Use

**2 Hours**

- Apprentice will identify ways to deal with drug abuse, state ways to keep their family free from alcohol and other drugs, and identify specific sources available for those in need of help.

## ProTech Skills Level One – Lesson Nine: This is a National Program

**2 Hours**

- Apprentice will Identify what the NJATC is, explain the history and responsibilities of the NJATC, the qualities of a superior training program, and the training attributes made possible through unity.

## ProTech Skills Level One – Lesson Ten: Becoming Familiar With the IBEW Constitution

**2 Hours**

- Apprentice will gain an understanding of the structure of the IBEW, as well as the rules and regulations established in the IBEW Constitution.

## ProTech Skills Level One – Lesson Eleven: Professional Personal Conduct

**2 Hours**

- Apprentice will learn traits that contribute to a sense of being a professional, behavior patterns that they can adopt to help perform as a professional, ways that they can continue to develop as an Electrical Worker, and the structure and roles that make up the organization.

## ProTech Skills Level One – Lesson Twelve: Absenteeism

**2 Hours**

- Apprentice will learn how absenteeism can be a contributing factor in on-the-job accidents, the true cost that absenteeism places on the company, and factors that do and do not contribute to absenteeism.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in ProTech and address highlights/questions. Introduce most commonly used symbols and IEEE device numbers. Electron flow mockup as relates to simple circuit. Electromotive force demonstration. Hot Line indicating and Personal Protective Grounding procedures. Assess tool use capabilities.\***

### **\*TEST FOR YEAR ONE: LEVEL ONE\***

## ProTech Skills Year One: Level Two

Materials: Building a Foundation in Mathematics Textbook, Test Instruments Textbook, DC Theory Textbook, Calculator, Web Resources, and Courseware

The first seven lessons in this course expose the student to everyday mathematical equations, with each lesson building upon the last. They take the student from basic math with whole numbers to working with powers of 10 and metric prefixes. The next lesson picks up on some of the metric concepts that have been introduced and expands on them to include the metric system of measurement. The next two lessons use the concepts learned in the previous eight lessons and present how to calculate the area and volume of a circle. The remaining four lessons introduce basic electrical concepts every substation technician must know. The lessons introduce current, voltage, and resistance in a circuit, and Ohm's Law. The course ends with a lesson that answers the question: What is electricity?

## ProTech Skills Level Two – Lesson One: Math Basics with Whole Numbers

**2 Hours**

- Apprentice will add, subtract, multiply, and divide whole numbers, learn skills in interpreting and solving word problems using whole numbers, the concept of negative numbers, and order of operations.

## ProTech Skills Level Two – Lesson Two: Fractions

**2 Hours**

- Apprentice will learn how to work with proper fractions, improper fractions, and mixed numbers to achieve the correct form required to solve specific problems, and reduce fractions to their simplest form. Apprentice will add, subtract, multiply, and divide numbers with fractions, and learn how to solve word problems involving fractions.

## ProTech Skills Level Two – Lesson Three: Decimals

**2 Hours**

- Apprentice will learn to convert fractions to decimal numbers and decimal numbers to fractions, and recognize common fraction and decimal equivalents. Apprentice will add, subtract, multiply, and divide decimal numbers, as well as learn how to solve word problems that involve decimal numbers.

## ProTech Skills Level Two – Lesson Four: Percentages

**2 Hours**

- Apprentice will learn to convert percentages to or from decimals and fractions, accurately calculate percentages, and gain skills in using percentages to express values and to solve word problems.

## ProTech Skills Level Two – Lesson Five: How to Solve Basic Algebraic Equations

**2 Hours**

- Apprentice will demonstrate their skill in developing algebraic formulas to solve word problems, demonstrate in class their ability to solve algebraic equations, and work with arithmetic signs of operation in setting up and solving algebraic definitions.

## ProTech Skills Level Two – Lesson Six: Working with Ratios and Proportions

**2 Hours**

- Apprentice will demonstrate knowledge and ability for solving ratio and proportion problems, demonstrate an understanding of mathematical rules as they apply to ratio and proportion problems, and recognize and solve problems involving both direct and inverse relationships.

## ProTech Skills Level Two – Lesson Seven: Working with Prefixes and Powers of Ten

**2 Hours**

- Apprentice will learn the value of metric prefixes, and how to convert from one prefix to another. Apprentice will change from prefixed numbers to whole numbers and from whole numbers to prefixed numbers, and use powers of ten to quickly perform basic mathematical functions.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Confirm basic math understanding based on current Pro Tech lessons. Math Quiz. Introduce simple series circuit. Build simple series circuit on Hampden board and other equipment. Quiz on commonly used device numbers and symbols. Quiz on beginning print numbers (E1s, E10s-E14s), disconnect numbering, PCB numbering, and cable numbering. Quiz on beginner single line reading. Intro to E2, E3, E5-E9, E15 prints. Beginner switching (Transmission PCB).\***

## ProTech Skills Level Two – Lesson Eight: The Customary and Metric Systems of Measurement

**2 Hours**

- Apprentice will gain knowledge and understanding of comparing the customary system with the metric system, how to accurately make mathematical conversions from customary to metric measurements, and explain the advantages of the metric system.

## ProTech Skills Level Two – Lesson Nine: The Circle

**3 Hours**

- Apprentice will learn to define radius, diameter, circumference, and area of a circle. Will learn how to calculate each of the measurements of a circle, and understand how  $\pi$  (pi) is used in those calculations.

## ProTech Skills Level Two – Lesson Ten: Area and Volume

**3 Hours**

- Apprentice will learn to state the formulas for finding the area of a rectangle, parallelogram, and triangle, state the formulas to find the volume of a rectangular prism and a cylinder, and solve math problems involving area and volume.

## ProTech Skills Level Two – Lesson Eleven: Current, Voltage, and Resistance in a circuit

**2 Hours**

- Apprentice will learn to define electricity, describe current flow and how current flows in a circuit. Apprentice will learn to define terms associated with current, voltage, and resistance, and be able to explain how to safely measure current, voltage, and resistance.

## ProTech Skills Level Two – Lesson Twelve: The Electrical Circuit and Ohm's Law

**2 Hours**

- Apprentice will learn to describe the operation of simple circuits, solve mathematical problems using Ohm's Law, and explain how and why prefix multipliers are used in equations and circuit values.

## ProTech Skills Level Two – Lesson Thirteen: Power in a Circuit

**3 Hours**

- Apprentice will learn to describe how electrical power is utilized or dissipated, mathematically solve circuit problems using Ohm's Law and/or Ohm's Law for power, and explain the units of measurement for both mechanical and electrical power.

## ProTech Skills Level Two – Lesson Fourteen: What is Electricity?

**3 Hours**

- Apprentice will learn to describe the basic structure of an atom, and name the three main particles which are part of all but the simplest atom. Apprentice will learn to describe the electrical characteristics of an atom, and describe the relation between valence (free) electrons and electron movement (current flow).

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Introduce simple parallel circuit. Build simple parallel circuit on Hampden board and other equipment. In/out and tap bus configuration. Switching (Transfer Breaker). Beginner conduit bending. Discuss where to find Operation and Maintenance Procedure Manual and what it entails. Quiz on Station Abbreviations. Ohm's Law in simple series and parallel DC circuit.\*

**\*TEST FOR YEAR ONE: LEVEL TWO\***

## ProTech Skills Year One: Level Three

Materials: Building a Foundation in Mathematics Textbook, Guidebook for Linemen and Cablemen Textbook, DC Theory Textbook, Web Resources, and Courseware.

The fundamentals of electricity and DC circuits are presented in this course and built upon with in-depth coverage of Ohm's Law and its relation to voltage, current, resistance, and power. Lessons also introduce electrical devices and cover the principles of magnetism.

### ProTech Skills Level Three – Lesson One: Electrical Energy Sources

**2 Hours**

- Apprentice will learn to identify and describe the different means of producing electric current, describe the makeup of a battery and explain how to determine polarity, and explain how electricity can create heat and light.

### ProTech Skills Level Three – Lesson Two: Electrical Switches

**2 Hours**

- Apprentice will learn to describe how a switch functions in a circuit and explain the terminology used to describe switches

### ProTech Skills Level Three – Lesson Three: Conductors, Conductor Resistance, and Wattage Loss

**2 Hours**

- Apprentice will learn to describe how conductors are sized, understand how to determine the resistance of a conductor, and explain how the material and the length of a conductor will affect the resistance, wattage loss, and voltage drop of the circuit.

### ProTech Skills Level Three – Lesson Four: Introduction to Electrical Devices

**2 Hours**

- Apprentice will learn to identify which component an electrical or electronic symbol represents when they see that symbol in a drawing or schematic and draw the correct symbols for electrical or electronic components when making schematic drawings. Apprentice will learn to identify different types of resistors as well as identify the value of a resistor by the color-coded bands.

### ProTech Skills Level Three – Lesson Five: The Series Circuit

**2 Hours**

- Apprentice will learn to explain the four basic rules to find values in a series circuit, as well as use Ohm's Law to solve unknown values in a circuit.

### ProTech Skills Level Three – Lesson Six: Understanding and Calculating Resistance in DC Series Circuits

**2 Hours**

- Apprentice will learn to draw and label basic components of electric circuits, calculate the total resistance in series circuits using both the formula for series resistance and Ohm's Law, and review the procedures for measuring resistance using a multimeter.

## ProTech Skills Level Three – Lesson Seven: How Current Reacts in DC Series Circuits

**2 Hours**

- Apprentice will learn to draw and label some new components and additional electrical circuits, and calculate the effect of changing voltages and resistances on circuit current. Apprentice will learn to determine how some circuits may be modified to control circuit current using Ohm's Law, as well as measure the current in a series circuit using either an analog or a digital meter.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Introduce simple parallel-series circuit. Build simple parallel-series circuit on Hampden board and other equipment. Distribution Main and Transfer bus configuration. Switching (Capacitor Bank Breaker). Discuss Red, Yellow, and Blue Tags. HLP in Operation and Maintenance Procedure Manual. Quizzes on Print numbers, cable numbers, device numbers, and equipment numbers.**

## ProTech Skills Level Three – Lesson Eight: Voltage in Series Circuits

**2 Hours**

- Apprentice will learn to use Ohm's Law to determine the voltage applied to a series circuit or to individual components in a series circuit, calculate the effective voltage applied to series circuits, and use analog and digital multimeters to measure voltages across series circuit components.

## ProTech Skills Level Three – Lesson Nine: How to Calculate Power in DC Series Circuits

**2 Hours**

- Apprentice will learn to draw and label series electrical circuits that contain power-rated devices, and calculate the total power used in series circuits. Apprentice will learn to calculate the power used by individual components in a series circuit, as well as calculate the power wasted in a circuit.

## ProTech Skills Level Three – Lesson Ten: How Current Reacts in a DC Parallel Circuit

**3 Hours**

- Apprentice will learn to describe how the current flow rule for parallel circuits differs from the current flow rule for series circuits, calculate the currents in individual branches of parallel circuits, and determine the total current in parallel circuits.

## ProTech Skills Level Three – Lesson Eleven: Understanding Resistance in DC Parallel Circuits

**3 Hours**

- Apprentice will learn to identify circuits containing parallel resistors, calculate the total circuit resistance of parallel circuits with two resistance values using the product-sum method, and calculate the total circuit resistance of parallel circuits with two or more resistance values using the reciprocal method.



## ProTech Skills Level Three – Lesson Twelve: How Voltage Functions in a DC Parallel Circuit

**3 Hours**

- Apprentice will learn to solve problems involving voltage in parallel circuits using Ohm's Law, identify and describe differences between voltage sources in series and parallel circuits, and describe how parallel circuit voltage rules differ from series circuit voltage rules.

## ProTech Skills Level Three – Lesson Thirteen: How to Calculate Power in a DC Parallel Circuit

**3 Hours**

- Apprentice will learn how to show the power required by each individual component in a parallel circuit, and calculate the total power consumed in a parallel circuit using the power consumed by individual components. Apprentice will also learn to calculate the total power consumed in parallel circuits from the source voltage and total current delivered to that circuit, as well as determine power ratings of components in parallel circuits.

## ProTech Skills Level Three – Lesson Fourteen: The Principles of Magnetism

**2 Hours**

- Apprentice will learn to explain the theories of magnetism, explain how electromagnetism performs useful and meaningful work, and demonstrate an understanding of magnetic materials through classroom discussion.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Introduce simple series-parallel circuit. Build simple series-parallel circuit on Hampden board and other equipment. Transmission Main and Transfer bus configuration. Switching (Feeder Breaker). Line naming. Prints (E4 and E8), discuss how circuits learned to this point relate to E4, and highlight similarities. Basic test switches. Basic transformer ratios. Basic transformer nameplate info.\*

**Total Step 1 = 88 Hours**

**\*TEST FOR YEAR ONE: LEVEL THREE\***

**\*PROGRESSION TEST (STEP 1 TO 2)\***

## **2<sup>nd</sup> Six Months (Step 2)**

### **ProTech Skills Year One: Level Four**

Materials: Guidebook for Linemen and Cablemen Textbook, NJATC Safety Handbook, Substation Construction and Guidelines Textbook, Hot Sticks Textbook, Live-Line Work Practices Textbook, Personal Protective Grounding for Worker Safety Textbook, Web Resources, and Courseware.

To be successful in this industry, a substation technician must be knowledgeable about the trade, highly skilled in the mechanics, and aware of the importance of safety on the job. This course introduces OSHA, the reasons for its formation and its regulations. Several lessons deal specifically with situations substation technicians face, such as structure rescue and fall protection. The course also includes lessons on grounding in substations and how to establish a protective grounding scheme in a substation and concludes with a lesson on the hazards of working outdoors.

#### **ProTech Skills Level Four – Lesson One: Introduction to OSHA**

**2 Hours**

- Apprentice will learn the reasons for the formation of and need for OSHA, the need for OSHA, the responsibilities of the employer under OSHA, the rights and responsibilities of the employee under OSHA, the basic regulations in 1910.269, 1926 subpart V, 1910.268, and the NESC and how they relate to each other.

#### **ProTech Skills Level Four – Lesson Two: Responsibility for Safety**

**2 Hours**

- Apprentice will learn the responsibilities of the employee to help control accidents, hazards that must be addressed during a job site briefing, and the requirements of a job site briefing.

#### **ProTech Skills Level Four – Lesson Three: Personal Protective Equipment**

**2 Hours**

- Apprentice will learn the proper type of PPE for the conditions that are present on the job, when PPE is required by the OSHA standards, and the limitations of PPE as they relate to their job site usage.

#### **ProTech Skills Level Four – Lesson Four: Electrical Awareness**

**2 Hours**

- Apprentice will learn what factors will affect the severity of an electrical shock, including various shock current intensities and their effects, the techniques and devices for protecting personnel against electrical accidents, as well as the definition of voltage gradients and ground-faults.

#### **ProTech Skills Level Four – Lesson Five: Energized and Non-Energized Parts**

**2 Hours**

- Apprentice will learn to distinguish energized line parts from other parts of electrical equipment, determine the nominal voltage of exposed, energized parts, as well as determine the distance that must be maintained when a qualified employee approaches exposed energized part.

## ProTech Skills Level Four – Lesson Six: Substation Construction – Safety and First Aid

**2 Hours**

- Apprentice will learn the requirements when administering first aid, learn distances workers may approach an energized line or piece of equipment, and learn the requirements of safety equipment.

## ProTech Skills Level Four – Lesson Seven: Live-Line Tools – Introduction, Identification, and Care

**2 Hours**

- Apprentice will learn to identify equipment used in live-line maintenance, the safety requirements of equipment involved with live-line work, as well as the procedures for repairing live-line tools.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Worksheet activity on Ohm's law and DC circuits. Switching (Bank Breaker). Breaker and a half bus configuration. How to obtain permit per Ops and Maintenance Procedure Manual. More complex circuit building on Hampden Board. Intro to CTs and associated ratios. More complex conduit bending. Quiz on ALL print numbers. Single lines in relation to bus configurations. Quiz on mathematical prefixes.**

## ProTech Skills Level Four – Lesson Eight: Fall Protection

**2 Hours**

- Apprentice will learn to identify job place working conditions that require fall protection, and discuss the fall protection options that are available once the need for fall protection has been established. State individual elements of each of the fall protection options as well as define the fall protection terms used throughout the fall protection standard.

## ProTech Skills Level Four – Lesson Nine: Baskets, Aerial Lifts, and Platforms

**2 Hours**

- Apprentice will learn to recognize associated hazards with the operation of aerial equipment, and understand the safe operation of aerial equipment. Apprentice will learn how to recognize safety labels and inspection points found on aerial equipment, as well as locate and understand operator's manuals.

## ProTech Skills Level Four – Lesson Ten: Substation Structure and Rescue

**3 Hours**

- Apprentice will learn the four basic steps in pole top rescue and the steps that should be followed when climbing to the rescue position. Apprentice will learn the steps required to lower a victim to the ground from the top of a substation transformer, as well as describe basic CPR.

## ProTech Skills Level Four – Lesson Eleven: Bucket Rescue

**3 Hours**

- Apprentice will learn how critical time is in a bucket rescue, the need for personal safety in bucket or aerial platform rescue, and the acceptable methods of bucket rescue.

## ProTech Skills Level Four – Lesson Twelve: Personal Protective Grounding – Grounding in Substations

**3 Hours**

- Apprentice will be able to recognize the different grounding requirements between substation work and remote site work, know the importance of placing the grounds close to the worker, and be able to recognize the hazards from the current and voltages present.

## ProTech Skills Level Four – Lesson Thirteen: Grounding and Protective Grounds

**3 Hours**

- Apprentice will learn the reasons for grounding electrical circuits and equipment, the hazards involved with system grounding, and the factors that affect the resistance of a ground path.

## ProTech Skills Level Four – Lesson Fourteen: Working Outdoors

**2 Hours**

- Apprentice will learn how weather conditions affect the job, where to find information on safety when working in different weather conditions, and how to protect oneself and one's coworkers when encountering different weather conditions.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Switching (Bank Clearance). Further worksheet activities on Ohm's law and DC circuits. Quiz on single lines and bus configurations. Transformer nameplate info, identifying windings. Basic differential (what goes in, must come out). Quiz on grounding and Hot Line Indicating procedures. Discuss PCB test equipment. CT ratios.\*

### **\*TEST FOR YEAR ONE: LEVEL FOUR\***

## **ProTech Skills Year One: Level Five**

Materials: Guidebook for Linemen and Cablemen Textbook, NJATC Safety Handbook, Lineworker Rigging Practices Textbook, Operator Manuals, Web Resources, and Courseware.

Because every Electrical Worker needs a basic knowledge of the tools of the trade, this course presents lessons on a wide variety of subjects. It begins with two lessons on identifying basic tools and the use and care of hand tools. This course explores the use and operation of blocks, slings, and chokers, as well as various rigging tools and equipment. It also explains the properties of ropes and how to use and care for them. This course discusses ladder safety topics including proper use, selection, and care. Lesson also introduce rigging tools and hardware, digger derricks, and the use of load charts associated with digger derricks. It concludes with a lesson on hand signals that are common to the electrical industry.

## ProTech Skills Level Five – Lesson One: Identify Some Basic Tools of the Trade

**2 Hours**

- Apprentice will learn about and be able to identify the more commonly used hand tools of the electrical industry.

## ProTech Skills Level Five – Lesson Two: Use and Care of Hand Tools

**2 Hours**

- Apprentice will learn the proper selection, safe application, and care for all tools of the trade, and how important proper tool usage is to safety, productivity, and the tool's life span. They will also learn how to use basic hand tools properly, as well as defects that make a tool unusable.

## ProTech Skills Level Five – Lesson Three: Protective Line Devices, Care and Use

**3 Hours**

- Apprentice will learn how rubber protective equipment and the Minimum Approach Distance (MAD) relate, and how to apply various insulating equipment over energized equipment. Apprentice will learn how line hoses are used, how ozone cutting of rubber equipment takes place in the field, and learn how to care for and use rubber goods and PPE.

## ProTech Skills Level Five – Lesson Four: Good Housekeeping

**2 Hours**

- Apprentice will learn considerations for establishing a safe, productive job site, the need for neatness on the job site, and how good housekeeping procedures affect the work environment.

## ProTech Skills Level Five – Lesson Five: Powered Equipment Safety – Compressors and Portable Generators

**2 Hours**

- Apprentice will learn the electrical hazards associated with generator use, the hazards associated with exhaust and gas fumes, the hazards associated with compressed air, and where and how to use a generator. Will also learn how to locate the OSHA requirements for noise levels and exposure limits.

## ProTech Skills Level Five – Lesson Six: Powered Equipment Safety – Underground

**2 Hours**

- Apprentice will learn the safe working distance from equipment, how to react to utility damage safely, how to maintain and service an underground machine as per the operator's manual, as well as state the importance of the operator's manual.

## ProTech Skills Level Five – Lesson Seven: Digging Holes and Trenches

**2 Hours**

- Apprentice will learn the methods used in digging, trenching, and boring, the safety precautions that should be taken whenever digging or trenching, and how to perform pole hole digging and sizing with power and manual methods.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Switching (Transfer bus clearance). Intro to center point grounding and its relation to DC ground monitoring (Diagram on board and then lab/practical on Hampden Board). Overcurrent protection discussion. Target identifying and reporting. Quiz on DC circuits/Ohm's Law. Intro to AC circuits and reactance. Layout activity. Discuss transformer testing equipment. CCVTs and their applications\*

## ProTech Skills Level Five – Lesson Eight: Ladders/Step Bolts

**2 Hours**

- Apprentice will learn how to select the right ladder for a job, and what needs to be checked on a ladder before it is put into use (including hook ladders), how to use ladders properly on the job site, and how to care for ladders.

## ProTech Skills Level Five – Lesson Nine: Ropes, Knots, Hitches, and Splices

**2 Hours**

- Apprentice will learn the advantages and limitations of various knots, hitches, and splices and be able to properly tie them, the properties of different types of fiber rope and selecting the proper rope for a given job, and how to properly care for rope.

## ProTech Skills Level Five – Lesson Ten: Use and Operation of Blocks

**2 Hours**

- Apprentice will learn how to calculate safe working loads and rigging methods for blocks, how to identify the various types of blocks used in electrical construction, as well as determine the proper application of blocks.

## ProTech Skills Level Five – Lesson Eleven: Slings and Chokers

**3 Hours**

- Apprentice will learn to determine safe working loads and rigging methods for slings and chokers, determine the proper application of slings and chokers, and the various types of slings and chokers that are commonly used in the electrical construction industry.

## ProTech Skills Level Five – Lesson Twelve: Rigging Tools and Rigging Equipment

**3 Hours**

- Apprentice will learn to determine the proper application of rigging hardware, determine safe loads for equipment, and identify rigging hardware components.

## ProTech Skills Level Five – Lesson Thirteen: Powered Equipment Safety – Digger Derricks

**2 Hours**

- Apprentice will learn the safe operation of digger derricks and the associated hazards with the operation of a digger derrick, interpret load charts and manuals, and state the location of safety labels and inspection points found on a digger derrick.

## ProTech Skills Level Five – Lesson Fourteen: Hand Signals

**3 Hours**

- Apprentice will learn the importance of hand signals in line work, demonstrate how to give basic hand signals for material handling and the ability to follow hand signals when given.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Switching (Taking feeder from independent bus to paralleled bus). Lab on CTs and PTs. Worksheet on ratios. Tap changer info and Ratios on Transformer nameplate.\***

**\*TEST FOR YEAR ONE: LEVEL FIVE\***

## ProTech Skills Year One: Level Six

Materials: Guidebook for Linemen and Cablemen Textbook, NJATC Safety Handbook, Substation Construction and Guidelines Textbook, Underground Distribution Textbook, Web Resources, and Courseware.

This course begins with an overview of the electric system in general and offers an introduction to the various types of substations a technician might encounter. The next five lessons present the groundwork that goes into building a substation. They cover building substation foundations, excavating trenches, building duct banks, and proper methods of backfilling and compacting a trench. Three lessons discuss the various cable types used in substations, how to safely pull cable, and how to install cable in vaults and manholes. This course concludes with two lessons on the substation ground grid. One lesson deals with ground grid construction and the last deals with the exothermic welding process used to join ground grid conductors together.

### ProTech Skills Level Six – Lesson One: The Electric System

**3 Hours**

- Apprentice will learn the distribution and transmission system, the different components that are involved in the electric system, and the different types of generating stations.

### ProTech Skills Level Six – Lesson Two: Introduction to Substations

**3 Hours**

- Apprentice will learn methods used in substations to interrupt an arc and thereby protect a feeder, the types of substations, and the types of equipment found in substations.

### ProTech Skills Level Six – Lesson Three: Substation Construction – Foundations

**2 Hours**

- Apprentice will be taught how to build a form to specifications, install anchor bolts and rebar to specifications, and pour concrete to specifications and finish it to specifications.

### ProTech Skills Level Six – Lesson Four: Working in Excavations and Trenches

**2 Hours**

- Apprentice will be taught the hazards associated with excavations and trenches, the duties of a competent worker as related to excavations and trenches, and OSHA's Subpart P safety requirements for excavations and trenches.

### ProTech Skills Level Six – Lesson Five: Excavating the Trench

**2 Hours**

- Apprentice will learn the hazards associated with trenches and how to protect workers against them, how to classify the soil types commonly found in trenches, and more on OSHA 1926, Subpart P safety requirements for trenches.

## ProTech Skills Level Six – Lesson Six: Laying Conduit/Building Duct Banks 2 Hours

- Apprentice will learn the different types of conduit systems, how to apply proper methods for installing a duct bank, and how to install conduit to the proper depth and use proper backfill methods.

## ProTech Skills Level Six – Lesson Seven: Manholes and Handholes 2 Hours

- Apprentice will be able to describe the purpose of manholes and vaults, and explain proper construction techniques in the building of a manhole or vault, including placement of a precast structure.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Switching (Box Loop). Clearances per Operations and Maintenance Procedures Manual. Best T disconnect to use per manual with box loop. Test switches for I/O and potentials. Lab on reading current. Conduit bending activity. Intro to combined device numbers.\***

## ProTech Skills Level Six – Lesson Eight: Trench Encasements, Backfill, and Compaction 2 Hours

- Apprentice will learn the proper way to tamp a trench containing a duct bank or conduit, the types of concrete used for duct bank encasement, as well as the types of material that should not be part of the backfill in a trench.

## ProTech Skills Level Six – Lesson Nine: Cable Types 2 Hours

- Apprentice will learn the different types of stranded conductors, explain the different types of insulations used, and identify the different components used in shielded and nonshielded cables.

## ProTech Skills Level Six – Lesson Ten: Substation Construction – Underground Power Cables 3 Hours

- Apprentice will learn about the fragile nature of underground cable, the proper methods of pulling and laying cable, the proper methods of splicing and terminating cable, and how to work safely around cables.

## ProTech Skills Level Six – Lesson Eleven: Pulling Cables 3 Hours

- Apprentice will learn how to set up the proper rigging and identify the different equipment used in pulling cable, how to follow general pulling practices and cautions, and how to follow proper safety techniques used in pulling cable.



## ProTech Skills Level Six – Lesson Twelve: Installing Cable in an Underground Vault/Manhole

**2 Hours**

- Apprentice will learn about the safety items used to prevent overstressing cable when being pulled in, how a blower is used when working in an enclosed space, and the different types of racks used in vaults/manholes to hold cables in place.

## ProTech Skills Level Six – Lesson Thirteen: Substation Construction – Ground Grids

**2 Hours**

- Apprentice will learn proper grounding and location of a substation fence, the connectors that are typically used when constructing a substation grid, and different methods that might be used to lower ground resistance when installing a substation ground grid.

## ProTech Skills Level Six – Lesson Fourteen: Exothermic Welding

**2 Hours**

- Apprentice will learn the safety procedures associated with applying an exothermic weld, and the technical procedures required to make a successful exothermic weld. They will learn the metals or combinations of metals where exothermic welding can be used in a substation, as well as why exothermic welded connectors are superior to squeeze-on connectors.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Switching (Full station clearance). Discuss what is still hot/energized during station clearance. Discuss ATS scheme with relation to station service and station service backups. Cover more on combined device numbers. Nomenclature quiz. Discuss fault coordination.\*

**Total Step 2 = 96 Hours**

**\*TEST FOR YEAR ONE: LEVEL SIX\***

**\*PROGRESSION TEST (STEP 2 TO 3)\***

**3<sup>rd</sup> Six Months (Step 3)**

## ProTech Skills Year Two: Level One

Materials: Building a Foundation in Mathematics Textbook, Substation Construction and Guidelines Textbook, Web Resources, and Courseware.

Level I opens with lessons that introduce the student to blueprints and specifications. Electrical drawings and diagrams, along with civil drawings, also are reviewed. Other lessons discuss what blueprint symbols mean and how drawings are scaled and dimensioned. This course also contains a lesson dealing with substation steel erection and a lesson that introduces measuring and leveling devices. The course concludes with a lesson on measuring and drawing angles and another on right triangles.

### ProTech Skills Level One – Lesson One: Symbols, Conventions, and Abbreviations

**3 Hours**

- Apprentice will be taught the purpose of symbols, conventions, and abbreviations used on blueprints, as well as what various symbols, conventions, and abbreviations represent. They will learn what information is available on the various drawings discussed, and describe the difference between standard and one-line electrical diagrams.

### ProTech Skills Level One – Lesson Two: Scaling and Dimensioning Drawings

**2 Hours**

- Apprentice will learn the difference between extension and dimension lines, the types of scales used on blueprints, and how dimensions are inserted into a blueprint.

### ProTech Skills Level One – Lesson Three: Single-Line Drawings

**2 Hours**

- Apprentice will learn the symbols used in a single-line diagram, the purpose of a single-line diagram, and how to read and understand single-line diagrams.

### ProTech Skills Level One – Lesson Four: Schematic Diagrams

**2 Hours**

- Apprentice will learn how to interpret the symbols used in a schematic diagram, why different color wires are used in a schematic diagram, and how to identify various components used in schematic diagrams.

### ProTech Skills Level One – Lesson Five: Electrical Drawings and Diagrams

**3 Hours**

- Apprentice will learn to identify the symbols for transformer connections and associated electrical equipment, the types of drawings and diagrams used to illustrate an electrical system or circuit, and what type of information is available in each kind of drawing and diagram discussed in this lesson.

## ProTech Skills Level One – Lesson Six: Introduction to Blueprints and Specifications

**3 Hours**

- Apprentice will learn about the information contained in construction drawings, the information that would be found on a specification sheet, the types of drawings used in electrical construction, as well as the primary uses of blueprints and specification sheets.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Written switching activity. Lab on inductive reactance in AC circuit. Current test switches. Quiz on ratios and transformer nameplate. More on combined device numbering. Lab on capacitive reactance in AC circuit. Quiz on target identifying and reporting. Simulate overcurrent fault in Ryan Training Yard.\***

## ProTech Skills Level One – Lesson Seven: Civil Drawings

**2 Hours**

- Apprentice will learn what methods an engineer uses to provide additional information other than the drawings, find specific information on various civil engineering drawings, recognize and identify the maps used to place a structure, and the difference between a note and a specification sheet.

## ProTech Skills Level One – Lesson Eight: Steel Erection Drawings

**2 Hours**

- Apprentice will learn how to associate the list of materials with a substation blueprint, how substation blueprints are laid out from overview to detail, and how to identify major station components from the blueprints.

## ProTech Skills Level One – Lesson Nine: Introduction to Measuring and Leveling Devices

**2 Hours**

- Apprentice will learn the function of the various tools and equipment used in surveying, the different types of measurements that are taken during a survey, and the proper procedures to follow when setting up measuring instruments.

## ProTech Skills Level One – Lesson Ten: Measuring and Drawing Angles

**3 Hours**

- Apprentice will learn about the different types of angles, how to measure and draw angles with a protractor, as well as how to calculate the measure of angles without the use of a protractor.

## ProTech Skills Level One – Lesson Eleven: Right Triangles

**3 Hours**

- Apprentice will learn how to calculate the unknown lengths and angles of a right triangle, how to use the Pythagorean Theorem, and identify different types of triangles.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Practical switching activity. Quiz on combined device numbers. Mathematically calculating single phase watts in an AC circuit.\***

**\*TEST FOR YEAR TWO: LEVEL ONE\***

## ProTech Skills Year Two: Level Two

Materials: Guidebook for Linemen and Cablemen Textbook, Substation Construction and Guidelines Textbook, Web Resources, and Courseware.

Level II deals with the groundwork needed when constructing a substation, from site layout and preparation to building an oil spill prevention containment system as required by the EPA. Lessons expand on previous lessons dealing with ground grids, equipment grounding, and the types of ground connectors available to the substation technician. The student will also learn about boom capacities, load charts, steel superstructure assembly, and erection. The last four lessons deal with installing insulators, bus/jumper types, and wire bus types.

### **ProTech Skills Level Two – Lesson One: Site Layout and Preparation**

**2 Hours**

- Apprentice will learn the factors that should be considered when picking a site for a substation, the types of rollers available, and how a rammer type soil compactor works.

### **ProTech Skills Level Two – Lesson Two: Equipment Foundations**

**2 Hours**

- Apprentice will learn about what should be checked on rebar prior to installation, the two most common types of foundations used in substation construction, and the proper way to install a template and anchor bolts prior to pouring a drilled foundation.

### **ProTech Skills Level Two – Lesson Three: Substation Construction – Spill Prevention, Containment, and Countermeasure Plans**

**3 Hours**

- Apprentice will learn the reasons a substation must have an SPCC plan, the methods used to contain an oil spill in a substation, and the requirements of an SPCC plan.

### **ProTech Skills Level Two – Lesson Four: Substation Construction – Grounding/Grounding Grids**

**2 Hours**

- Apprentice will learn how to understand the purpose of a substation ground grid, how to construct a ground grid, and how a ground grid contributes to worker and public safety.

### **ProTech Skills Level Two – Lesson Five: Type of Ground Connectors**

**2 Hours**

- Apprentice will learn the IEEE standard that rates the maximum allowable temperatures for connectors, the PPE that must be worn when installing exothermic connectors, and the most common types of connectors used on substation ground grids.

### **ProTech Skills Level Two – Lesson Six: Boom Capacities and Load Charts**

**3 Hours**

- Apprentice will learn how to use the load charts to calculate a safe lift for a given weight, the set-up procedures for a truck with a mounted boom, how a truck may tip over with little or no weight at the boom tip, and the procedures for the safe operation of booms.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. In house lesson on 3 part communication and phonetic alphabet. Mathematically calculating single phase vars in an AC circuit.\*

## **ProTech Skills Level Two – Lesson Seven: Insulated Platforms and the Second Point of Contact**

**3 Hours**

- Apprentice will be introduced to the concept of the second point of contact, the insulated platform and its purpose, and the methods used for protection from the second point of contact.

## **ProTech Skills Level Two – Lesson Eight: Superstructure Assembly and Erection Part One**

**2 Hours**

- Apprentice will learn the most popular types of steel structures used in substation construction, the OSHA standard that applies to steel erection, and the differences between the two most popular types of steel structures.

## **ProTech Skills Level Two – Lesson Nine: Superstructure Assembly and Erection Part Two**

**2 Hours**

- Apprentice will learn the proper way to connect onto a load using shackles and slings, how to properly bolt structures together, and the items that need to be considered on every lifting job.

## **ProTech Skills Level Two – Lesson Ten: Insulators**

**3 Hours**

- Apprentice will learn to identify different types of insulators, how insulators are made and their individual characteristics, as well as how to determine where specific types of insulators should be used.

## **ProTech Skills Level Two – Lesson Eleven: Bus/Jumpers – Types**

**3 Hours**

- Apprentice will learn the types of substation bus arrangements, methods used to stop bus vibration, and the common size of aluminum hollow tube used for substation buses.

## **ProTech Skills Level Two – Lesson Twelve: Bus/Jumpers – Proper Handling, Installations**

**3 Hours**

- Apprentice will learn how a Deutsch compression type connector is applied, the types of welding that are used to join aluminum bus work, and the advantages of welding substation bus work.

## **ProTech Skills Level Two – Lesson Thirteen: Wire Bus Type**

**3 Hours**

- Apprentice will learn the techniques used to prepare a wire bus before crimping on a spade terminal, the types of aluminum wire that are used for buses, as well as the proper way to warm up a torque wrench.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Simulated “on air” switching activity. Ohm’s Law review. Intermediate circuits on Hampden Board. Mathematically calculating three phase watts in an AC circuit.\*

## **\*TEST FOR YEAR TWO: LEVEL TWO\***

### **ProTech Skills Year Two: Level Three**

Materials: Guidebook for Linemen and Cablemen Textbook, Substation Construction and Guidelines Textbook, AC Theory Textbook, Web Resources, and Courseware.

Level III covers equipment specific to substations. The first two lessons are an overview of substation equipment and each of the remaining lessons concentrates on specific pieces of substation equipment beginning with the power transformer and ending with lightning arrestors. The lessons explain the function of each piece of equipment and point out the hazards associated with them. Besides the equipment mentioned, this course covers capacitors, reactors, rectifiers, voltage regulators, and switches.

#### **ProTech Skills Level Three – Lesson One: Substation Equipment Overview 2 Hours**

- Apprentice will learn about the methods used in substations to interrupt an arc and thereby protect a feeder, the types of substations, as well as the types of equipment found in substations.

#### **ProTech Skills Level Three – Lesson Two: Equipment Identification 2 Hours**

- Apprentice will learn the safety factors associated with substations, how different pieces of substation electrical equipment perform their functions, and be able to discuss an electrical line inside a substation yard and the pieces of equipment attached to it.

#### **ProTech Skills Level Three – Lesson Three: Power Transformers 3 Hours**

- Apprentice will learn how to test a substation transformer’s oil, the methods for cooling transformer oil, how cooling the transformer oil allows for greater capacity, and the different voltages of substation power transformers.

#### **ProTech Skills Level Three – Lesson Four: Substation – Air Switches 2 Hours**

- Apprentice will learn the types of switches used in substations for isolating or grounding a line, the method used by sulfur hexafluoride switches to open a circuit, and the safety factors associated with operating switches in a substation yard.

## ProTech Skills Level Three – Lesson Five: Voltage Regulators

**3 Hours**

- Apprentice will learn the importance of maintaining good voltage, how voltage is affected by electrical system changes, and be able to explain how the voltage on a line can be regulated.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Mathematically calculating three phase vars in an AC circuit. Discuss sine, cosine, tangent, Pythagorean Theorem in relation to conduit bending\*

## ProTech Skills Level Three – Lesson Six: Capacitors

**3 Hours**

- Apprentice will learn the causes of system low power factor, the ways a capacitor functions, and be able to describe how a capacitor reduces power factor.

## ProTech Skills Level Three – Lesson Seven: Reactors

**3 Hours**

- Apprentice will learn the application of reactors in substations, which type of reactor would be used on the end of a lightly loaded transmission line, and the major types of reactors used in substations.

## ProTech Skills Level Three – Lesson Eight: Rectifiers

**2 Hours**

- Apprentice will learn the reasons HVDC may become the preferred way of transmitting large amounts of power, the function of a valve hall, and the possible advantage of using DC instead of AC for transmission lines.

## ProTech Skills Level Three – Lesson Nine: Protective Equipment

**3 Hours**

- Apprentice will learn the common types of lightning protection used for substations, the classes of lightning arrestors used in substations, and the different mediums used in substation breakers to extinguish an arc.

## ProTech Skills Level Three – Lesson Ten: Lightning Protection

**2 Hours**

- Apprentice will learn the characteristics of a lightning strike, the characteristics of lightning arrestors, and the types of lightning arrestors used in different applications.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Generating principles. In house lessons on generation on company LMS. Live station activity on current and voltage reading. Testing a CT ratio using the voltage method (discuss how percentages apply).\*

**Total Step 3 = 85 Hours**

**\*TEST FOR YEAR TWO: LEVEL THREE\***

**\*PROGRESSION TEST (STEP 3 TO 4)\***

# **4<sup>th</sup> Six Months (Step 4)**

## **ProTech Skills Year Two: Level Four**

Materials: Guidebook for Linemen and Cablemen Textbook, DC Theory Textbook, AC Theory Textbook, Web Resources, and Courseware.

Level IV starts with a review of the applications of DC theory and is followed by lessons dealing with resistance, current, voltage, and power in combination circuits. The student will then compare DC to AC and be introduced to generators and the fundamentals of AC. The course concludes with a lesson on inductance and another on the causes and effects of voltage drop.

### **ProTech Skills Level Four – Lesson One: Reviewing the Applications of DC Theory**

**2 Hours**

- Apprentice will define voltage, current, resistance, and power, how voltage, current, and resistance function in series and parallel circuits, the basic Ohm's Law formulas as they apply to DC Theory, and work a variety of DC Theory mathematical problems correctly, which will aid in the study of AC Theory.

### **ProTech Skills Level Four – Lesson Two: Understanding Resistance in DC Combination Circuits**

**2 Hours**

- Apprentice will learn how to identify circuits that are classified as combination or series-parallel circuits, analyze components in a combination circuit to determine whether they are connected in series or parallel with other components, and apply the rules learned for series and parallel resistors to reduce a circuit to its equivalent resistance.

### **ProTech Skills Level Four – Lesson Three: How Current Reacts in Combination Circuits**

**2 Hours**

- Apprentice will learn how to apply Ohm's Law to determine the current through any branch or component of a combination circuit, determine which components will carry total circuit current in combination circuits, and how to identify alternative current paths in combination or series-parallel circuits.

### **ProTech Skills Level Four – Lesson Four: How Voltage Functions in DC Combination Circuits**

**2 Hours**

- Apprentice will learn to apply Ohm's Law to determine the voltage drop across components in combination circuits, how to calculate the total or equivalent resistance of groups of components in combination circuits, and how to calculate current flow through components or through complete combination circuits



## ProTech Skills Level Four – Lesson Five: How to Calculate Power in DC Combination Circuits

**2 Hours**

- Apprentice will be taught how to calculate the total power consumed in a DC combination circuit, calculate the power consumed by a component (or group of components), in a DC combination circuit, and when given the power consumption, determine each circuit component's current, voltage, and resistance value.

## ProTech Skills Level Four – Lesson Six: Comparing Direct Current to Alternating Current

**3 Hours**

- Apprentice will learn the distinct characteristics of alternating and direct current, how to apply Ohm's Law to understand the advantage of using alternating current for power distribution, the definition of terms used to express the characteristics of AC waveforms, and how the values of AC waveforms are represented by the sine wave.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Live station activity on power flow. Intermediate circuits on Hampden Board. Worksheet on watts and vars (single and 3 phase). E2 and E3 prints with relation to CTs, PTs, and CCVTs.\*

## ProTech Skills Level Four – Lesson Seven: Fundamentals of Alternating Current

**3 Hours**

- Apprentice will learn how an AC waveform can be represented graphically as a sine wave, define the terms cycle, frequency, period, alternation, sine wave, and instantaneous values, as well as how to mathematically calculate values of AC parameters including effective value/voltage, average value/voltage, maximum value/voltage, and peak-to-peak values/voltages.

## ProTech Skills Level Four – Lesson Eight: An Introduction to 3-Phase Systems

**3 Hours**

- Apprentice will learn the relationship between the voltages or currents in different phases of a 3-phase power system, the physical differences between wye and delta 3-phase connections, and how to calculate current and voltage parameters of both wye and delta 3-phase systems.

## ProTech Skills Level Four – Lesson Nine: Understanding How the DC Generator Works

**3 Hours**

- Apprentice will learn the major parts of the DC generator, the principles and operation of the DC generator, and the different types of losses in a generator.

## ProTech Skills Level Four – Lesson Ten: Understanding the Design and Function of AC Generators

**3 Hours**

- Apprentice will learn the operation of AC generators, the key parts of the AC generators and their functions, and how to mathematically determine the relationships between RPM, frequency, and the number of poles.

## ProTech Skills Level Four – Lesson Eleven: Introduction to Inductance

**2 Hours**

- Apprentice will learn about the principles of electromagnetic induction, how to define inductance, self-inductance, and mutual induction, and the physical factors that affect inductance.

## ProTech Skills Level Four – Lesson Twelve: Voltage Drop

**3 Hours**

- Apprentice will learn about the variety of conditions that can affect voltage drop, how to make calculations concerning line loss, as well as how wire size affects voltage drop.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Quiz on intermediate circuits on Hampden Board. Quiz on watts and vars (single and 3 phase). Quiz on Substation portion on Operation and Maintenance Procedure Manual.

### **\*TEST FOR YEAR TWO: LEVEL FOUR\***

## ProTech Skills Year Two: Level Five

Materials: Guidebook for Linemen and Cablemen Textbook, Test Instruments Textbook, NJATC Safety Handbook, Transformation for Lineworkers Textbook, Distribution Volume One Textbook, AC Theory Textbook, Web Resources, and Courseware.

Level V begins with a general safety awareness lesson, which is followed by a lesson on substation applications of lock-out/tag-out. The next lessons are on single-phase transformers and cover an introduction to transformers, their construction and characteristics, and how they operate. Single-phase connections are also reviewed. The lessons dealing with the installation of transformers help the students understand some of the pit-falls they may face when working with single-phase transformers. This course concludes with two lessons on the use of test instruments.

## ProTech Skills Level Five – Lesson One: Safety Awareness – On the Job

**3 Hours**

- Apprentice will learn the need for everyone on a job site to work in an alert and safety-conscious manner, identify positive, safe attitudes as well as negative, dangerous ones, common safety practices employed in the industry, and the possible negative repercussions of an accident.

## ProTech Skills Level Five – Lesson Two: Lockout/Tagout – Substation Applications

**3 Hours**

- Apprentice will learn the requirements for training under the lockout/tagout program, the elements necessary for all lockout/tagout programs, and how to differentiate between lockout and tagout in use and in application.

## ProTech Skills Level Five – Lesson Three: Introduction to Transformers

**2 Hours**

- Apprentice will learn about the different types of transformers, how a transformer coils and core function, as well as the basic theory of electromagnetic induction.

## ProTech Skills Level Five – Lesson Four: Transformer Construction

**2 Hours**

- Apprentice will be able to describe factors that contribute to transformer heating, explain describe the internal leads brought out from transformer coils, state factors that contribute to transformer losses, and describe, identify, and explain the material and components used in a transformer.

## ProTech Skills Level Five – Lesson Five: Transformer Information Characteristics

**2 Hours**

- Apprentice will learn about what is found on transformer nameplates, the coil capacity of transformers connected in series and parallel, and be able to differentiate between internal transformer coils in series or parallel.

## ProTech Skills Level Five – Lesson Six: Vectors

**3 Hours**

- Apprentice will learn about the purpose of vectors as used in electrical drawings, how to figure the phase-to-phase voltage on a wye-connected bank, and be able to draw a vector diagram for a 3-phase bank connected wye-delta 0° displacement.

## ProTech Skills Level Five – Lesson Seven: Transformer Operation

**3 Hours**

- Apprentice will learn how to differentiate between the functions of a potential and a current transformer, describe and apply transformer ratios, and learn about Michael Faraday's contribution to the invention of the transformer. Apprentice will learn why the transformer will not work on direct current systems, and be able to discuss transformer winding taps.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Advanced circuits on Hampden Board. Quiz on switching. Watts and vars simulation in Ryan Training Yard. Square D distribution PCB E4 scheme on screen, following close scheme.

## ProTech Skills Level Five – Lesson Eight: Transformer Polarity/Connections

**3 Hours**

- Apprentice will learn the safety procedures prior to paralleling single-phase transformers, how to describe the internal polarity of a single-phase transformer, how to diagram the proper way to set up equipment to check polarity on a single-phase transformer, and learn industry standards as they apply to transformer polarity.

## ProTech Skills Level Five – Lesson Nine: Tap Changers and Tap Changer Operation

**3 Hours**

- Apprentice will learn about how a transformer's output voltage is changed using taps, the equipment needed to check load, and how to figure load on a single-phase transformer.

## ProTech Skills Level Five – Lesson Ten: Installing Transformers

**2 Hours**

- Apprentice will learn about the secondary terminal connections for a single-phase transformer, the pre-installation checks to be performed prior to installing a transformer, the bird-guard function as used on transformers, and transformer fusing as it relates to the protection of a transformer.

## ProTech Skills Level Five – Lesson Eleven: Single-Phase Transformer Connections

**2 Hours**

- Apprentice will learn about the connections that can be made with a single-phase transformer, the difference between series and parallel coils, and the safety checks to be made prior to paralleling transformers.

## ProTech Skills Level Five – Lesson Twelve: Transformer Protection

**3 Hours**

- Apprentice will learn about the function of fuses as they relate to protecting a transformer, underground transformer fuse protection, the effects of transformer overheating, and the effects of transformer loading on the operation of a transformer.

## ProTech Skills Level Five – Lesson Thirteen: Introduction to Test Instruments

**2 Hours**

- Apprentice will learn the precautions required to properly care for test instruments, the historical development of measuring standards and methods, the use of safety labels, procedures, equipment, and standards as they apply to the use of test instruments, and learn how to identify the causes of common measurement errors and the techniques used to reduce them.

## ProTech Skills Level Five – Lesson Fourteen: General Use Test Instruments

**2 Hours**

- Apprentice will learn the different types of voltage and current test instruments and their relative advantages and disadvantages, how to safely use various voltage or current test instruments to identify electrical power problems, the different types of voltage and current and the terminology used to describe them, the different types of multimeters and understand how their features are useful in troubleshooting, and how to understand the concepts of resistance and continuity and safely use an ohmmeter or megohmmeter.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Advanced circuits on Hampden Board. Square D distribution PCB E4 scheme on screen, following trip scheme. Discuss ring bus configuration\*

**\*TEST FOR YEAR TWO: LEVEL FIVE\***

## ProTech Skills Year Two: Level Six

Materials: Guidebook for Linemen and Cablemen Textbook, Personal Protective Grounding Textbook, Substation Construction Guidelines Textbook, Transformation for Lineworkers Textbook, Distribution Volume One Textbook, AC Theory Textbook, Web Resources, and Courseware.

Level VI starts with a review on how to conduct transformer load checks. Three-phase connections and voltages are covered and the lessons on single-phase transformers wrap up with information on ferroresonance and the specific hazards a substation technician may encounter when working with transformers. The next lessons include topics on step and touch potentials, equipotential zone grounding, and how to test ground (earth) resistance. This course concludes with two lessons that discuss subjects that substation technicians will be dealing with on a regular basis: power factor and power harmonics.

### **ProTech Skills Level Six – Lesson One: Conducting Transformer Load Checks 3 Hours**

- Apprentice will learn how to determine the equipment needed to check load on a single-phase transformer, how to figure load on a single-phase transformer, and how to calculate the kilovolt-amperes being drawn from a single-phase transformer.

### **ProTech Skills Level Six – Lesson Two: Transformers – 3 Phase Connections 3 Hours**

- Apprentice will learn how to apply the wye and delta voltage and current laws to banking single-phase transformers, how to calculate full load currents at various points in wye-wye and delta-delta banks, as well as how to identify angular displacements and vector line drawings of wye-wye and delta-delta banks.

### **ProTech Skills Level Six – Lesson Three: Transformers – 3 Phase Voltages 3 Hours**

- Apprentice will be able to explain voltages across and currents through transformer coils and lines in delta systems, as well as voltages across and currents through transformer coils and lines in wye systems. Discuss the advantages and disadvantages of higher voltage distribution systems, as well as the advantages of poly-phase systems.

### **ProTech Skills Level Six – Lesson Four: Specific Hazards Working with Transformers 3 Hours**

- Apprentice will learn the safety procedures prior to working on transformers, how to avoid back-feed, and the items to look for prior to energizing a transformer.

### **ProTech Skills Level Six – Lesson Five: Ferroresonance 2 Hours**

- Apprentice will learn what conditions must be present for ferroresonance to occur, measures that can be taken on an existing transformer bank to prevent ferroresonance, and equipment that could fail because of ferroresonance overvoltage.

## ProTech Skills Level Six – Lesson Six: PPG – Grounding in Substations

**2 Hours**

- Apprentice will learn about the different grounding requirements between substation work and remote site work, the importance of placing the grounds close to the worker, and how to recognize the hazards from the current and voltages present.

## ProTech Skills Level Six – Lesson Seven: PPG – Step and Touch Potential

**2 Hours**

- Apprentice will learn how to understand both step potential and touch potential, and the difference between them, the protection methods available for these hazards, and understand that contact with the earth is not always  $V = 0$ .

## ProTech Skills Level Six – Lesson Eight: PPG – Equipotential Zone Grounding

**2 Hours**

- Apprentice will be able to define an equipotential zone, recognize the benefits of an equipotential zone over other methods of grounding, and how to use equipment to establish an equipotential zone of protection.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Quiz on advanced circuits on Hampden Board. Square D distribution PCB E4 scheme on screen, highlighting potential areas of trouble. Discuss a and b contacts. Quiz utilizing full station prints.\***

## ProTech Skills Level Six – Lesson Nine: Testing Ground (Earth) Resistance

**2 Hours**

- Apprentice will learn what factors influence the resistivity of the earth, the regulations or standards pertaining to ground rods, and the methods used to measure or improve resistivity of ground rods.

## ProTech Skills Level Six – Lesson Ten: Substation Inspection

**2 Hours**

- Apprentice will learn about the items associated with substation fences that should be checked, the maximum temperature allowed for a substation main transformer, and the items that should be checked in a substation battery room.

## ProTech Skills Level Six – Lesson Eleven: Substation CTs, VTs, and PTs

**3 Hours**

- Apprentice will learn the three types of current transformers in common use, the function of CTs and PTs in a substation, and the main safety issue when working with CTs.

## ProTech Skills Level Six – Lesson Twelve: Power Factor

**3 Hours**

- Apprentice will learn about the electrical influences that make up a power factor, the benefits of keeping the power factor of a circuit high, and the measures taken to control the power factor in a circuit.

## ProTech Skills Level Six – Lesson Thirteen: Power Harmonics

**3 Hours**

- Apprentice will learn the basics of harmonic interference, and recognize harmonics as a possible source of customer complaints.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. “Find the problem” activity in Ryan Training Yard. Discuss what happens when lockout rolls. ABB transmission PCB E4 scheme on screen, following close scheme.\*

**Total Step 4 = 98 Hours**

**\*TEST FOR YEAR TWO: LEVEL SIX\***

**\*PROGRESSION TEST (STEP 4 TO 5)\***

**5<sup>th</sup> Six Months (Step 5)**

## **ProTech Skills Year Three: Level One**

Materials: Web Resources and Courseware

Power transmission construction is one of the fastest growing electrical industries. Substations and switchyards are key components of power transmission. The substation technician has to be highly trained in electrical construction and also be a productive leader. Level I opens with lessons on taking pride in the industry and understanding union by-laws and parliamentary procedures. Students then will have an introduction to the COMET program and learn about the National Electrical Benefit Fund and labor management relations. They then will learn about the hazards of cell phone use in the workplace and the economics of unemployment. The remaining lessons cover motivation and leadership, foremanship, and Journeyman responsibilities.

## ProTech Skills Level One – Lesson One: Almost a Journeyman

**2 Hours**

- Apprentice will be able to explain the “why” and “how” of apprenticeship, why all workers in the industry need to be highly productive and efficient, and assess how much training is needed before becoming a Journeyman Electrical Worker.

## ProTech Skills Level One – Lesson Two: Pride in Your Industry

**2 Hours**

- Apprentice will define the word *pride*, list the qualities inherent to pride, discuss the positive personal and occupational benefits of developing pride, and explain how the industry's future is impacted by pride, or the lack thereof.

## ProTech Skills Level One – Lesson Three: Understanding Local Union Bylaws

**2 Hours**

- Apprentice will learn what topics are addressed in local union bylaws, how to use the bylaws to answer questions regarding local union policies and procedures, and how the bylaws affect the operation of the local union.

## ProTech Skills Level One – Lesson Four: Parliamentary Procedure and How it Works

**2 Hours**

- Apprentice will be taught parliamentary procedure, how to understand the responsibility, authority, and role of the chairperson, and to abide by parliamentary rules when granted the privilege to attend and participate in local union meetings.

## ProTech Skills Level One – Lesson Five: An Introduction to the COMET Program

**2 Hours**

- Apprentice will be taught the IBEW's COMET Program, the basic elements of construction that apply to the need to organize, and the ways that an apprentice can assist in the organizing effort in the local area.

## ProTech Skills Level One – Lesson Six: The National Electrical Benefit Fund

**2 Hours**

- Apprentice will be taught the history, growth, and development of the NEBF, as well as given basic knowledge of benefits paid by the NEBF.

## ProTech Skills Level One – Lesson Seven: Productivity

**2 Hours**

- Apprentice will learn about the cost of a job in regards to labor, materials, and equipment, the factors that contribute to lost crew time on the job, the factors that define a good crew, and define professionalism.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. ABB transmission PCB E4 scheme on screen, following trip scheme. Hazards of a missed step in switching and our responsibilities in that capacity. Discuss breaker and a half bus configuration.\***

## ProTech Skills Level One – Lesson Eight: Hazards of Cell Phone Use in the Workplace

**2 Hours**

- Apprentice will learn about some of the dangers associated with cell phone use while driving, some of the statistics associated with traffic accidents and cell phone use, and the financial toll of cell phone-related crashes in the U.S.



## ProTech Skills Level One – Lesson Nine: Labor-Management Relations/LMCC's

**2 Hours**

- Apprentice will learn the importance of labor-management relations, the terms that are used in negotiations, and the methods that can be used to resolve issues of a labor agreement.

## ProTech Skills Level One – Lesson Ten: The Economics of Unemployment

**2 Hours**

- Apprentice will learn about the importance of having a personal savings plan, the qualities that can have a positive effect on continuous employment, and be able to describe the "independence" of working in the construction industry. Apprentice will learn how unemployment compensation works, and the need for a sound, well-thought-out financial budget and responsible spending.

## ProTech Skills Level One – Lesson Eleven: Keys to Success-Motivation and Leadership

**2 Hours**

- Apprentice will learn some basic theories on motivation, the levels of human need, which leadership action to choose to deal with various worker attitudes and abilities, and why leadership in electrical construction is important.

## ProTech Skills Level One – Lesson Twelve: After Apprenticeship

**2 Hours**

- Apprentice will be able to demonstrate an ability to constructively critique and evaluate personal performance, how to begin to plan for ways and means to contribute to the electrical industry after completing the apprenticeship, and to demonstrate a desire and willingness to be active in the IBEW and in political activities affecting the nation at all levels.

## ProTech Skills Level One – Lesson Thirteen: Foremanship

**2 Hours**

- Apprentice will learn about the traits of a responsible Foreman, how to recognize the importance of being a responsible Foreman, as well as some of a Foreman's duties and how they can affect the outcome of a job.

## ProTech Skills Level One – Lesson Fourteen: Soon to be an Instructor

**2 Hours**

- Apprentice will learn the qualities of a competent and conscientious Qualified Electrical Worker, the essential steps involved in quality instruction, how all Journeymen Electrical Workers are instructors and what their responsibilities are, and the need for political activism.

## ProTech Skills Level One – Lesson Fifteen: Your Career-Journeyman Responsibilities

**2 Hours**

- Apprentice will learn about the attributes that a Qualified Electrical Worker should have, the college credits available for Qualified Electrical Workers after apprenticeship, and the responsibilities of a Qualified Electrical Worker.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. ABB transmission PCB E4 scheme on screen, highlighting potential areas of trouble. Apply DC ground in Ryan Training Yard and have students follow along with how to locate ground using proper troubleshooting methods and following best practice and safety procedures.\*

## **\*TEST FOR YEAR THREE: LEVEL ONE\***

### **ProTech Skills Year Three: Level Two**

Materials: Guidebook for Linemen and Cablemen Textbook, Personal Protective Grounding Textbook, Substation Construction Guidelines Textbook, NJATC Safety Handbook, Substation Operation and Maintenance Textbook, Web Resources, and Courseware.

There are many facets to substation construction that must be mastered. Safety is primary in both deenergized and energized situations. One of the significant dangers is arc flash. Level II discusses guidelines to prevent arc flashes, utilization of rubber protective devices, and general safety in substations and switchyards. Grounding of all components, including vehicles, is also covered. In addition, power quality and distribution circuits are explained.

#### **ProTech Skills Level Two – Lesson One: OSHA 1910.269(u)**

**2 Hours**

- Apprentice will learn the safety precautions to take when working on energized substation equipment, the OSHA standard that applies directly to substations, and the safety procedures to be taken when operating a draw-out type circuit breaker.

#### **ProTech Skills Level Two – Lesson Two: Arc Flash Compliance**

**2 Hours**

- Apprentice will learn the standard where personal protective equipment (PPE) requirements for arc flash protection can be found, the effects of an arc flash that can cause injury, and the physical characteristics of an arc flash.

#### **ProTech Skills Level Two – Lesson Three: Temporary Grounding For Substations**

**2 Hours**

- Apprentice will learn the safety procedures when grounding a vehicle in a substation yard, the proper placement of temporary grounds at a substation, how to properly ground a portable ground mat at a substation, and the main danger from grounding leads when they are subjected to a ground fault.

#### **ProTech Skills Level Two – Lesson Four: PPG-Induced Voltage and Multiple Grounds**

**2 Hours**

- Apprentice will learn the difference between induced and fault current levels, the sources of induced voltage and current, and the protection needed for induced voltage and current.

## ProTech Skills Level Two – Lesson Five: Selection Of Equipment and Installation of Grounds

**2 Hours**

- Apprentice will learn the OSHA standards that governs grounding for employee protection, the proper order of applying and removing temporary grounds, the types of grounding clamps that are allowed to be used as part of grounding assemblies, and the dangers of using temporary grounds that are too long, should they become energized.

## ProTech Skills Level Two – Lesson Six: Vehicle Grounding

**2 Hours**

- Apprentice will learn about the worker's part in the total circuit, what is required to maintain worker safety when working around trucks, and learn proper truck grounding.

## ProTech Skills Level Two – Lesson Seven: Applying Rubber Protective Devices

**2 Hours**

- Apprentice will learn the voltage levels that may be worked with rubber gloves, the types of cover-up protective equipment, and safe working positions when working with rubber gloves.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. GE transmission PCB E4 scheme on screen, following close scheme, and highlighting possible problem areas. Discuss breaker sync check and application of permissive contact in that regard. Discuss line differential protection.\*

## ProTech Skills Level Two – Lesson Eight: PPG- Body Currents

**2 Hours**

- Apprentice will learn the impact of current on the human body, the importance of maintaining and providing adequate protection levels against electrical shock, and the relationship between current level and time of duration in current flow and the human body.

## ProTech Skills Level Two – Lesson Nine: Live-Line Tools-Using Hot Sticks

**2 Hours**

- Apprentice will learn the most common sticks used by a Qualified Electrical Worker working on a substation, how to use a telescoping, and how to apply a heavy ground set to a substation bus.

## ProTech Skills Level Two – Lesson Ten: Power Quality

**2 Hours**

- Apprentice will learn the minimum voltage a 120/240-volt customer should have, the ways a power provider can improve power quality, as well as the factors that might result in television interference.

## ProTech Skills Level Two – Lesson Eleven: Substation Voltages

**2 Hours**

- Apprentice will learn the divisions of transmission voltage, how to calculate the current-carrying capacity difference between two levels of transmission voltages, and the reasons why increasing voltage is cheaper than building a new transmission line.

## ProTech Skills Level Two – Lesson Twelve: Distribution Circuits Overview

**2 Hours**

- Apprentice will learn about the voltages that are typically found on distribution circuits, the different types of distribution systems most commonly in use, and why an electrical provider would find it cheaper to increase the voltage in a distribution system from 7,200 volts to 13,800 volts than from 2,400 volts to 13,800 volts.

## ProTech Skills Level Two – Lesson Thirteen: Substations-Operation and Maintenance

**3 Hours**

- Apprentice will learn the basic terminology used in substations, the major pieces of equipment used to create a substation, the equipment used to monitor and control a substation, as well as a few key items to inspect when maintaining a substation.

## ProTech Skills Level Two – Lesson Fourteen: Safety in Substations and Switchyards

**3 Hours**

- Apprentice will be taught basic substation hazards, how to ensure a worker is qualified to work unescorted in an energized station, how to perform work in a safe manner, and how to react when danger is imminent or an incident should happen.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. GE transmission PCB E4 scheme on screen, following trip scheme, and highlighting possible problem areas. Discuss breaker failure protection, it's consequences, targets, causes.\*

**\*TEST FOR YEAR THREE: LEVEL TWO\***

## ProTech Skills Year Three: Level Three

Materials: Guidebook for Linemen and Cablemen Textbook, Underground Distribution Textbook, Terminations and Splices Theory-Practice, Reference Guide to Fiberoptics, NJATC Safety Handbook, Web Resources, and Courseware.

The lessons in Level III cover cable splicing and the components of safety, materials and tools, cable preparation, terminations, elbows, grounding, and all phases of testing. The final three lessons provide an introduction to fiber optics, optical fiber, and connectors and splices. Fiber optic cables are quickly becoming the primary communication path of control and data throughout the entire transmission network.

## ProTech Skills Level Three – Lesson One: Cable Splicing-Safety

**2 Hours**

- Apprentice will learn more about electrical job safety, what is involved in cable splicing safety procedures, the basic steps for preparing to work underground in a manhole or aerially in a bucket, and how to work safely around medium and high voltages.

## ProTech Skills Level Three – Lesson Two: Cable Splicing-Material and Tools

**2 Hours**

- Apprentice will learn the different types of material used in making a medium voltage splice or termination, the different types of tapes used in making a splice or termination, the tools used in making a medium voltage splice or termination, and the different types of stranded conductors used in medium voltage cable.

## ProTech Skills Level Three – Lesson Three: Cable Splicing-Cable Preparation

**2 Hours**

- Apprentice will learn how to identify the workmanship causes of cable accessory failures, will learn cable preparation steps, starting with the jacket and ending with the conductor, how to select and use the proper traditional hand tool or special mechanical cable preparation tool, and learn the critical importance that cable preparation plays in cable accessory installations.

## ProTech Skills Level Three – Lesson Four: Cable Splicing-Terminations

**2 Hours**

- Apprentice will learn how to distinguish between low-voltage and high-voltage terminations. Will learn the important parts of a termination, the best lug application for a termination, as well as the atmospheric considerations when building a termination.

## ProTech Skills Level Three – Lesson Five: Cable Splicing-Splicing

**2 Hours**

- Apprentice will learn the importance of good cable preparation, the functions of a splice as they relate to the functions of cables, how to select a splice kit to match the cables being joined, and how to calculate cable preparation dimensions from a manufacturer's instructions.

## ProTech Skills Level Three – Lesson Six: Cable Splicing-Elbows (Separable Connectors)

**2 Hours**

- Apprentice will be taught the terminology used with elbow products, how to select between 200-ampere and 600-ampere elbows, and how to distinguish between deadbreak and loadbreak installations. Will learn how to operate (make or break) an elbow connection using a shotgun stick, and proper kit assembly procedures used for installing an elbow.

## ProTech Skills Level Three – Lesson Seven: Cable Splicing-Grounding Cables

**2 Hours**

- Apprentice will learn the importance of grounding a shielded power cable, the advantages and disadvantages of single-point grounding, double-end grounding, shield breaks, cross bonding, quarter mile grounding, and concentric neutral grounding, and selecting a grounding method for a specified job vs. a non-specified job. Will be taught how to install a cable ground using a constant force spring and ground braid, as well as connect a concentric neutral cable to ground and to a pre-molded accessory grounding tab.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. ABB R-MAG distribution scheme on screen. Follow trip and close paths, and highlight potential problem areas. Discuss trip and lockout path for bank breaker. Discuss permissive contact used for timer for capacitor breaker. Discuss fault coordination with regards to a feeder and bank breaker.\***

## ProTech Skills Level Three – Lesson Eight: Cable Splicing-Insulation Testing

**2 Hours**

- Apprentice will learn the purposes of cable testing, the types of cable tests most commonly performed, and the conditions that affect a cable's condition.

## ProTech Skills Level Three – Lesson Nine: Cable Splicing-Introduction to Cable Fault Locating

**2 Hours**

- Apprentice will learn the safety precautions that must be followed when a thumper is used to locate a cable, the procedure to follow when using a thumper to surge a cable, as well as conditions that may exist that will not allow a thumper to locate a fault.

## ProTech Skills Level Three – Lesson Ten: Cable Splicing-Underground Troubleshooting

**2 Hours**

- Apprentice will learn the reasons cable may fault other than lightning or traffic accidents, what a Qualified Electrical Worker has control over to prevent cable failure, the procedure for using a grounding spike, and things to look for when doing a piece-by-piece system inspection.

## ProTech Skills Level Three – Lesson Eleven: Cable Splicing-Manufacturer's Kits

**2 Hours**

- Apprentice will learn about the importance of training and craftsmanship required for installing manufactured kits, the IEEE standards that apply to splice, termination, and elbow kits, the different types of manufacturers' kits, how to select a proper kit based on cable, application, and environmental information, and to follow a manufacturer's kit instructions.

## ProTech Skills Level Three – Lesson Twelve: Introduction to Fiber Optics

**2 Hours**

- Apprentice will be taught how to define “fiber optics”, how fiber was developed and used in communications, and learn the difference between “outside plant” and “premises” fiber optics. Will learn the advantages of fiber optics, identify fiber optics standards, and how to work with fiber safely.

## ProTech Skills Level Three – Lesson Thirteen: Optical Fiber

**2 Hours**

- Apprentice will learn how optical fiber transmits light, the physical characteristics of various types of fibers, and how to understand fiber performance specifications.

## ProTech Skills Level Three – Lesson Fourteen: Connectors and Splices

**2 Hours**

- Apprentice will learn the difference between connectors and splices, and the requirements for connectors and splices. Will learn how to identify connector styles, identify types of connector terminations, identify splice types, and understand splicing procedures.

**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Siemens distribution scheme on screen. Follow trip and close paths, and highlight potential problem areas. Southern States MOD scheme on screen. Follow trip and close paths, highlight potential problems, and discuss use of “b” contact in close and trip scheme coming from bank breaker to prevent opening or closing under load. Discuss coupling mechanism and 33 position switch.\*

**Total Step 5 = 88 Hours**

**\*TEST FOR YEAR THREE: LEVEL THREE\***

**\*PROGRESSION TEST (STEP 5 TO 6)\***

**6<sup>th</sup> Six Months (Step 6)**

## **ProTech Skills Year Three: Level Four**

Materials: : Guidebook for Linemen and Cablemen Textbook, Test Instruments Textbook, Substation Operation and Maintenance Textbook, AC Theory Textbook, Web Resources, and Courseware.

There is much to understand about power transformer operations in substations. In these Level IV lessons, transformer principles, inspection and testing, tap changers, and oil quality are discussed in great detail. Along with these components, there are many tests to understand, such as insulation power factor testing, resistance testing, temperature indicator testing, and pressure relay testing. Various methods of insulation, including SF<sub>6</sub> gas and its proper handling, are also covered.

## ProTech Skills Level Four – Lesson One: Power Transformer Principles

**2 Hours**

- Apprentice will learn the basics of how a transformer functions, some of the terminology of transformers, how to differentiate between the different types of power transformers, and how different types of power transformers perform their job.

## ProTech Skills Level Four – Lesson Two: Power Transformers- Inspections and Tests

**2 Hours**

- Apprentice will learn the basic physical inspection of a transformer, the internal inspections performed on transformers, the apprehension and shipping of transformers by a utility, and the basic inspection of a new transformer.

## ProTech Skills Level Four – Lesson Three: Power Transformers- Tap Changers and Turns Ratio Testing

**2 Hours**

- Apprentice will learn the basic functioning of a tap changer, the difference between a load and no-load tap changer, and the safe way to perform work on a transformer. Will be taught the basic principle of turns ratio, how to identify a turns ratio test set, and how to calculate a turns ratio.

## ProTech Skills Level Four – Lesson Four: Transformer Oil Quality/Oil Filtration

**2 Hours**

- Apprentice will learn why transformer oil requires testing, how to take oil samples, the items found in test results that show transformer malfunctions, and basic transformer oil tests and their testing requirements.

## ProTech Skills Level Four – Lesson Five: DC High Potential Testing (Hi-Pot)

**2 Hours**

- Apprentice will learn the basic characteristics of a hi-pot tester, why a hi-pot test is performed, the basics of performing a hi-pot test, and safe handling practices while using a hi-pot tester.

## ProTech Skills Level Four – Lesson Six: Insulation Power Factor Test

**2 Hours**

- Apprentice will be taught the basic principles of power factor, why power factor testing is performed, the basic characteristics of the power factor test, and the basic processes of performing a power factor test.

## ProTech Skills Level Four – Lesson Seven: Insulation Resistance Test

**2 Hours**

- Apprentice will be taught the purpose of insulation resistance testing, the equipment used to perform insulation resistance testing, the procedures used to conduct the test, and how to interpret the test results.



**\*Classroom** – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Westinghouse distribution scheme on screen. Follow trip and close paths, and highlight potential problem areas. Discuss line protection for Zone 1, Zone 2, and Zone 3. Discuss measures taken to prevent “islanding” for battery systems and independent generation, and revisit permissive contacts in that application. Discuss the hazards associated with “motoring” a generator.\*

## **ProTech Skills Level Four – Lesson Eight: Power Transformer Temperature Indicator Testing**

**2 Hours**

- Apprentice will learn the reason power transformer temperature indicators are utilized, the components of a transformer temperature indicator, how a temperature indicator works, and the basic principles of testing a power transformer temperature indicator.

## **ProTech Skills Level Four – Lesson Nine: Power Transformer Pressure Relay Testing**

**2 Hours**

- Apprentice will learn how power transformer pressure relays are utilized, the components of a transformer pressure relay, how a pressure relay works, and how to test a power transformer pressure relay.

## **ProTech Skills Level Four – Lesson Ten: SF6 Gas-Properties**

**2 Hours**

- Apprentice will be taught the basic traits of sulfur hexafluoride gas, the products created by decomposing SF6 gas, the protective equipment that should be used when working with decomposed SF6, as well as basic treatment applied when coming into contact with decomposed SF6.

## **ProTech Skills Level Four – Lesson Eleven: SF6 Gas-Handling**

**2 Hours**

- Apprentice will learn how to safely handle SF6 gas and its decomposition products, basic gas handling requirements, the basics of handling SF6 decomposition products, and how to clean equipment that has suffered a fault that produced decomposition products.

## **ProTech Skills Level Four – Lesson Twelve: Vacuum Bottle Hi-Pot Testing**

**2 Hours**

- Apprentice will be taught why vacuum interrupters are used, where vacuum interrupters are used, and how to safely perform a high-potential (hi-pot) test.

## **ProTech Skills Level Four – Lesson Thirteen: Oil Containment**

**2 Hours**

- Apprentice will be taught why oil containment rules were created, the materials used to create an oil containment, the different types of oil containments, and why different oil containment types are used.

## ProTech Skills Level Four – Lesson Fourteen: Temporary Substations-Mobile Units

**2 Hours**

- Apprentice will be taught why mobile transformers are important in the power grid, what capacities and components make up a mobile substation, the characteristics of a mobile substation, as well as where and why mobile transformers are used.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. ABB R-MAG voltage checkout on trip and close schemes in Ryan Training Yard. Function checkout for all associated devices in breaker (local/remote switch, HLP tagging relay, test switches, etc.). Bus differential discussion. Show how to identify zones of protection, associated relaying, and test switch locations on E2 and E3 prints.\***

### **\*TEST FOR YEAR THREE: LEVEL FOUR\***

## ProTech Skills Year Three: Level Five

Materials: Substation Operation and Maintenance Textbook, Web Resources, and Courseware.

Circuit breakers perform an important role by preventing the enormous available power from destroying equipment, along with protecting human life. In Level V, the various operational, maintenance, and inspection and testing requirements of circuit breakers are covered. Time-travel characteristics of circuit breakers are also explored in respect to proper selective coordination. The lessons also discuss the roles of capacitors, reactors, voltage regulators, and simple components such as raptor protection and animal control. Bus configuration, connections, welding, and infrared thermography lessons are included.

## ProTech Skills Level Five – Lesson One: Circuit Breaker Operation

**2 Hours**

- Apprentice will learn about the basic operating principles of circuit breakers, which breaker types are used at which voltages, the different types of circuit breakers, as well as the different types of operating mechanisms used in circuit breakers.

## ProTech Skills Level Five – Lesson Two: Circuit Breaker Maintenance

**2 Hours**

- Apprentice will learn how to perform a visual inspection of a circuit breaker, how to clean a circuit breaker to allow for an inspection, the steps involved in a circuit breaker inspection, and why different circuit breakers require different inspections.

## ProTech Skills Level Five – Lesson Three: New Circuit Breaker Inspections and Tests

**2 Hours**

- Apprentice will learn the important parts of a circuit breaker to inspect upon delivery, when to perform new circuit breaker inspections and tests, basic circuit breaker tests, and basic circuit breaker bushing inspections and tests.

## ProTech Skills Level Five – Lesson Four: Circuit Breaker Time-Travel Characteristics

**2 Hours**

- Apprentice will be taught the terminology used to explain circuit breaker operation, the components that create a circuit breaker operation, and some of the signs of a faulty operating system.

## ProTech Skills Level Five – Lesson Five: Circuit Breaker Time-Travel Testing and Analysis

**2 Hours**

- Apprentice will be taught how to define a time-travel test, the test equipment used to perform a time-travel test, the basics of using each test set, and how to interpret the test results of a time-travel test and note when the breaker is not operating correctly.

## ProTech Skills Level Five – Lesson Six: Contact Resistance Testing

**2 Hours**

- Apprentice will learn the basic parameters of a contact resistance test, how to identify a contact resistance test set and correctly use the test set, how to connect the test set to a circuit breaker and perform the test, and how to connect the test set to a disconnect switch and perform the test.

## ProTech Skills Level Five – Lesson Seven: Capacitors and Reactors

**3 Hours**

- Apprentice will learn the basics of how power factor affects the electrical system, how to safely perform capacitor bank maintenance, how to safely perform reactor maintenance, and why reactors are connected differently in different circuits.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Square D distribution breaker voltage checkout on trip and close schemes in Ryan Training Yard. Function checkout for all associated devices in breaker (local/remote switch, HLP tagging relay, test switches, etc.). Southern States MOD voltage checkout on trip and close schemes in Ryan Training Yard. Function checkout for all associated devices.\***

## ProTech Skills Level Five – Lesson Eight: Capacitor Bank Maintenance and Testing

**3 Hours**

- Apprentice will be taught how to properly prepare a capacitor bank to be worked on, how to perform maintenance on a capacitor bank, and how to test and analyze the results on a capacitor bank.

## ProTech Skills Level Five – Lesson Nine: Voltage Regulators

**3 Hours**

- Apprentice will learn the basics of voltage regulator operation, the basics of voltage regulator controls, how to perform a voltage regulator inspection, as well as how to replace a regulator.

## ProTech Skills Level Five – Lesson Ten: Bus Configurations

**2 Hours**

- Apprentice will learn how to identify bus configurations from one-line drawings, why one bus configuration is more reliable than another, how to define electrical bus and how it is used in a substation, and why GIS might sometimes be chosen as a substation option.

## ProTech Skills Level Five – Lesson Eleven: Bus Connections

**2 Hours**

- Apprentice will learn the basics about electrical bus, how to identify common bus connection traits, and how to perform a bolted bus connection and a compression connection on bus.

## ProTech Skills Level Five – Lesson Twelve: Bus Welding

**2 Hours**

- Apprentice will learn the basic properties of aluminum bus, why welded bus connections are used, which tools and methods are used to weld aluminum bus, as well as how defective welds happen.

## ProTech Skills Level Five – Lesson Thirteen: Infrared Thermography

**2 Hours**

- Apprentice will learn the reasons for performing an infrared thermography survey, what is required to become a qualified thermographer, the examinations that are required to become a thermographer, as well as how to maintain a thermographer's license.

## ProTech Skills Level Five – Lesson Fourteen: Raptor Protection and Animal Guards

**2 Hours**

- Apprentice will learn why animal protection is important in a substation, which animals cause the most problems in substations, some common deterrents used in substations, and how to identify animal protection measures installed in substations.

## ProTech Skills Level Five – Lesson Fifteen: Alternative Energy Sources

**2 Hours**

- Apprentice will learn the basics of wind power, how solar power is used to create electricity, why hydroelectric power is used today, and why geothermal and hydrogen power are still distant generation sources.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Siemens distribution breaker voltage checkout on trip and close schemes in Ryan Training Yard. Function checkout for all associated devices in breaker (local/remote switch, HLP tagging relay, test switches, etc.). Discussion on underfrequency protection and overfrequency restoration. Discuss feeder prioritization per Operation and Maintenance Procedure Manual.\***

**\*TEST FOR YEAR THREE: LEVEL FIVE\***

## ProTech Skills Year Three: Level Six

Materials: Substation Operation and Maintenance Textbook, Guidebook for Linemen and Cablemen Textbook, Substation Construction Guidelines Textbook, Web Resources, and Courseware.

Level VI focuses on substation controls and the monitoring of all systems and components. Control devices include protective relays and transmission system controllers. These systems communicate through power line carriers utilizing system control and data acquisition (SCADA) equipment. The monitoring of substation components are not only for observing healthy conditions, but for analyzing short circuits and identifying distribution line faults. These systems must have constant power to operate at all times; therefore, lessons on substation batteries and uninterruptible power supplies ☐ and their maintenance and testing requirements ☐ are included. The final lessons discuss the procedures of commissioning and energizing a substation.

### ProTech Skills Level Six – Lesson One: Substation Control Rooms

**2 Hours**

- Apprentice will learn the requirements for installing cable in a substation, the types of meters used when installing cable and relays, and the characteristics of current transformers (CTs) and potential or voltage transformers (PTs or VTs).

### ProTech Skills Level Six – Lesson Two: Protective Relays

**3 Hours**

- Apprentice will learn how to identify the different elements of protective relays, how to recognize the different types of protective relays, and how to understand the functions of protective relays.

### ProTech Skills Level Six – Lesson Three: Protective Relays and Transmission Systems

**3 Hours**

- Apprentice will learn the type, operation, and function of transmission protective relays, the purpose and operation of “transfer tripping” and the communication channels used to accomplish transfer tripping, and the components and operation of a breaker failure relaying system.

### ProTech Skills Level Six – Lesson Four: Control Equipment

**3 Hours**

- Apprentice will learn about the different types of control equipment used for control and protection of the components of a transmission and distribution (T&D) system, how to identify the control systems needed for the protection of distribution feeders, transmission feeders, station fault control, and station source fault control, and how to perform a routine check of control equipment.

### ProTech Skills Level Six – Lesson Five: Power Line Carrier

**2 Hours**

- Apprentice will learn how a power line carrier system works and why it is used, the equipment needed for a power line carrier system, and what function power line carrier equipment performs.

## ProTech Skills Level Six – Lesson Six: Supervisory Control and Data Acquisition

**3 Hours**

- Apprentice will learn about the equipment required in a SCADA system, the functions of SCADA and why SCADA systems are used, and how SCADA systems are configured.

## ProTech Skills Level Six – Lesson Seven: Short Circuit Analysis-Testing for Distribution Line Faults

**2 Hours**

- Apprentice will learn the three different types of line faults, the difference between the types of line faults, and the methods used to locate line faults.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. Westinghouse distribution breaker voltage checkout on trip and close schemes in Ryan Training Yard. Function checkout for all associated devices in breaker (local/remote switch, HLP tagging relay, test switches, etc.). Discussion on transformer differential Protection and sudden pressure backup protection.**

## ProTech Skills Level Six – Lesson Eight: Metering

**2 Hours**

- Apprentice will learn about how metering is performed in a substation, the basic fundamentals of a current transformer and a voltage transformer, and the installation practices of metering equipment.

## ProTech Skills Level Six – Lesson Nine: AC/DC Generators

**2 Hours**

- Apprentice will learn the basic components of a backup generator and how they perform station backups, as well as the basic maintenance of a generator.

## ProTech Skills Level Six – Lesson Ten: UPS-Uninterruptible Power Supplies

**2 Hours**

- Apprentice will learn what a UPS is, what a UPS is for, become familiar with various types of power disturbances, and become familiar with UPS types and configurations.

## ProTech Skills Level Six – Lesson Eleven: Substations-Batteries

**2 Hours**

- Apprentice will learn about the types of load that substation batteries must support in case of a power outage, the voltages that are associated with substation batteries, and the safety concerns associated with substation batteries.

## ProTech Skills Level Six – Lesson Twelve: Substation Battery Testing

**2 Hours**

- Apprentice will learn how to complete voltage and resistance tests, how to complete a specific gravity test, how to complete integrity and capacity tests, and how to complete an impedance test.

## ProTech Skills Level Six – Lesson Thirteen: Substation Battery Chargers

**2 Hours**

- Apprentice will learn the functions and the components of a substation battery charger, the different types of charges available and when each type of charge is needed, and how to conduct periodic inspections and make needed adjustments.

## ProTech Skills Level Six – Lesson Fourteen: Substation, Cell and Charger Replacement

**2 Hours**

- Apprentice will learn how to replace a cell while continuing to provide DC protection to the system, how to replace a battery while continuing to provide DC protection to the system, and how to replace a battery charger while continuing to provide DC protection to the system.

## ProTech Skills Level Six – Lesson Fifteen: Commissioning a Substation

**2 Hours**

- Apprentice will be taught why and when commissioning is performed, the equipment in a substation that requires commissioning, and how to commission the supervisory control and data acquisition (SCADA) system.

**\*Classroom – Discuss recent jobs/tasks in the field amongst class, utilizing Q&A. Discuss current level in Pro Tech and address highlights/questions. GE Transmission breaker voltage checkout on trip and close schemes in Ryan Training Yard. Function checkout for all associated devices in breaker (local/remote switch, HLP tagging relay, test switches, etc.). Follow trip and lockout path from PCB to control house and back. Discussion on automated station restoration with transformer protection operation.**

**Total Step 6 = 95 Hours**

**\*TEST FOR YEAR THREE: LEVEL SIX\***

**\*PROGRESSION TEST (STEP 6 TO 7)\***

# **7<sup>th</sup> Six Months (Step 7)**

The following 6 months is post Pro Tech and will show a monthly breakdown of topics and activities covered.

## **Month 1**

Cross training with Relays. Breaker sabotage and troubleshooting for ABB R-MAG distribution feeder PCB using continuity method. Breaker sabotage and troubleshooting for ABB R-MAG distribution feeder PCB using voltage method. Station restoration exercise after simulation of line protection outage. Highlight zone of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**

## **Month 2**

Cross training with Lines. Breaker sabotage and troubleshooting for ABB R-MAG distribution transfer PCB using continuity method. Breaker sabotage and troubleshooting for ABB R-MAG distribution transfer PCB using voltage method. Station restoration exercise after simulation of bus protection outage. Highlight zone of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**

## **Month 3**

Cross training with Distribution and Transmission Operations. Breaker sabotage and troubleshooting for ABB R-MAG distribution bank PCB using continuity method. Breaker sabotage and troubleshooting for ABB R-MAG distribution bank PCB using voltage method. Station restoration exercise after simulation of transformer differential protection outage. Highlight zone of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**

## **Month 4**

Cross training with Meter Shop. Breaker sabotage and troubleshooting for Westinghouse distribution PCB using continuity method. Breaker sabotage and troubleshooting for Westinghouse distribution PCB using voltage method. Station restoration exercise after simulation of transformer sudden pressure protection outage. Highlight zone of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**



## **Month 5**

Cross training with Substation Inspectors. Breaker sabotage and troubleshooting for Siemens distribution PCB using continuity method. Breaker sabotage and troubleshooting for Westinghouse distribution PCB using voltage method. Station restoration exercise after simulation of transformer sudden pressure protection outage. Highlight zone of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**

## **Month 6**

Cover textbook chapters left over from Pro Tech that were not covered in its curriculum, but deemed pertinent by instructor. Breaker sabotage and troubleshooting for Square D distribution PCB using continuity method. Breaker sabotage and troubleshooting for Square D distribution PCB using voltage method. Station restoration exercise after simulation of both transformer sudden pressure and transformer differential protection outage. Highlight zones of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**

**Total Step 7 = 90 Hours**

## **\*PROGRESSION TEST (STEP 7 TO 8)\***

## **8<sup>th</sup> Six Months (Step 8)**

The following 6 months is the final 6 months and will show a monthly breakdown of topics and activities covered. It will not conclude with a step progression test, but rather a series of final "Top Out" tests.

## **Month 1**

Various company LMS lessons deemed pertinent by instructor to supplement learning. Breaker sabotage and troubleshooting for GE transmission PCB using continuity method. Breaker sabotage and troubleshooting for GE transmission PCB using voltage method. Station restoration exercise after simulation of breaker failure protection outage. Highlight zone of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**

## **Month 2**

Various company LMS lessons deemed pertinent by instructor to supplement learning. Sabotage of station potentials in various forms. Highlight possible causes, procedures, permits to take, and appropriate troubleshooting measures. Station restoration exercise after simulation of both line and bus protection packages outage. Highlight zones of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**

## **Month 3**

Witness live test of station automated restoration. Various scenarios to be simulated and tested. Simulate station DC ground in various forms. Highlight possible causes, procedures, permits to take, and appropriate troubleshooting measures. Various 12kv restoration exercises/scenarios after simulation of various 12kv outages. Highlight the different zones of protection, what targets to look for, and steps to successfully restore station.

**15 Hours**

## **Month 4**

Various written quizzes on textbook and on the job knowledge as preparation and review for finals.

**15 Hours**

## **Month 5**

Various written quizzes on switching scenarios, as well as hands on practical application as preparation and review for finals.

**15 Hours**

## **Month 6**

Various troubleshooting scenarios for practice as preparation and review for finals.

**15 Hours**

**Total Step 8 = 90 Hours**

**\*FINAL TOP OUT TESTING\***

**TOTAL PROGRAM CLASS HOURS = 730 Hours**

