
Substation Electrician

The following is an outline of the subjects to be covered in the supplementary classroom and home study training:

<u>Process</u>	<u>Hours</u>
Breakers	840
Transformers	850
Regulators/LTC	300
Relays	40
Batteries	100
Motor Operators	50
Transformer Shop	40
Misc. Repair & Maintenance	740
Training	250
Maintenance/Repair	Total 3210
General	600
Breakers	1000
Transformers	800
Regulators/LTC	150
Switches	640
Wiring	1200
Misc. Construction	400
Construction	Total 4790
Classroom Training & Home Study	800
Total OJT Hours Recommended: 8,000	

Step 1 (Months 1 thru 6)
Safety, Training, Math,
Prints & Tools
Total Hours for Step 1 = 96

Topic	Material	Hours
Safety, Training, and Print Reading	NJATC Substation course year 1, Level 1, corresponding NJATC material; NVE Safety Manual; NVE one-line prints, switching diagrams Apprentice expectations form List of tools IBEW 1245 contract Joint apprentice agreement contract	32

Lesson:

- Review Apprentice expectations and list of tools
- Introduction to IBEW 1245 contract
- Introduction and review of the Joint Apprentice agreement contract
- Review applicable sections on the NV Energy Safety Manual
- Substation Entry Training Class
- Generation tour (origin of power in our system)
- Transmission and Distribution system voltages, basic electricity (Ohm's Law)
- Substation specific tools and materials
- Introduction to substation equipment, components and basic function
- Identify equipment and very basic relaying/protection and ANSI device numbers

Topic	Material	Hours
Mathematics chapter 1-4	Building a Foundation in Mathematics, NJATC courses, and books	16

Lesson:

- Chapter 1 – Whole Numbers
- Chapter 2 – Fractions
- Chapter 3 – Decimals
- Chapter 4 – Integers

Topic	Material	Hours
Mathematics chapter 5-7	Building a Foundation in Mathematics, NJATC courses, and books	16

Lesson:

- Chapter 5 – Rational Numbers

- Chapter 6 – Exponents
- Chapter 7 – Logarithms

Topic	Material	Hours
Mathematics chapter 8-10	Building a Foundation in Mathematics, NJATC courses, and books	16

Lesson:

- Chapter 8 – Units and Measurements
- Chapter 9 – Algebra Essentials
- Chapter 10 – Equations, Formulas, and Inequalities

Topic	Material	Hours
Step One Progression Test Inspect tool bag that they have purchased full tool list	Syllabus all materials gone over in months 1-5 (safety, one lines, basic utility, math 1-10), List of tools	16

Lesson:

- Review and preparation for progression test
- Tool bag inspection

Step 2 (Months 7 thru 12)
Math, Knot
Tying/Rigging & Conduit
Bending
Total Hours for Step 2 = 96

Topic	Material	Hours
Mathematics chapter 11-13	Building a Foundation in Mathematics, NJATC courses, and books	16

Lesson:

- Chapter 11 – Ratios, Rates, and Proportions
- Chapter 12 – Percents
- Chapter 13 – The Cartesian Plane

Topic	Material	Hours
Mathematics chapter 14-16	Building a Foundation in Mathematics, NJATC courses, and books	16

Lesson:

- Chapter 14 – Systems of Equations
- Chapter 15 – Plane Geometry

- Chapter 16 – Solid Geometry

Topic	Material	Hours
Mathematics chapter 17-20	Building a Foundation in Mathematics, NJATC courses, and books	16

Lesson:

- Chapter 17 – Trigonometry
- Chapter 18 – Vectors
- Chapter 19 – Binary, Octal, and Hexadecimal Numbers
- Chapter 20 – Boolean Algebra Fundamentals

Topic	Material	Hours
Knot Tying and Rigging	Rigging and Lifting Principles NJATC course, books IBEW – Knot Tying and Rigging Workshop	16

Lesson:

- Hands on workshop and practicing knot tying

Topic	Material	Hours
Conduit Bending	NJATC course, books, workshop	16

Lesson:

- Hands on workshop and practicing conduit bending.

Topic	Material	Hours
Step Two Progression Test	Syllabus all materials gone over in months 7-11 (Math 11-20, Knot tying rigging, Conduit Bending)	16

Lesson:

- Review and preparation progression test

Step 3 (Months 13 thru 18)
DC Theory, Batteries Total
Hours Step 3 = 96

Topic	Material	Hours
Print Reading	Three-line diagrams, Wiring diagrams, ANSI device numbers, NVE standards, breaker schematic	8

Lesson:

- In-depth print reading, review NVE standards, complex prints.

Topic	Material	Hours
DC Theory Level 1-2	DC theory courses 1 and 2 with textbook and corresponding NJATC Blended Learning Courses/Material	8

Lesson:

- Electrical Energy Sources
- Electrical Switches
- DC Series Circuits
- Test Instruments

Topic	Material	Hours
DC Theory Level 3	DC theory courses 3 with textbook and corresponding NJATC Blended Learning Courses/Material	16

Lesson:

- How Current Reacts in DC Parallel Circuits – Ch. 5
- Understanding Resistance in DC Parallel Circuits – Ch. 5
- Working with Ratios and Proportion
- How Voltage Functions in DC Parallel Circuits – Ch. 5
- How to Calculate Power in DC Parallel Circuits – Ch. 5

Topic	Material	Hours
DC Theory Level 4	DC theory courses 4 with textbook and corresponding NJATC Blended Learning Courses/Material	16

Lesson:

- Understanding Resistance in DC Combination Circuits – Ch. 6
- How Current Reacts in DC Combination Circuits – Ch. 6
- How Voltage Functions in DC Combination Circuits – Ch. 6
- How to Calculate Power in DC Combination Circuits – Ch. 6

- How Voltage and Current Dividers Work – Ch. 7
- The Design and Operation of the 3-Wire, Single-Phase System

Topic	Material	Hours
DC Theory Level 5	DC theory courses 5 with textbook and corresponding NJATC Blended Learning Courses/Material	16

Lesson:

- Applying the Principle of Superposition to Circuit Calculations – Ch. 7
- Kirchhoff's Laws – Ch. 7
- Thevenin's and Norton's Theorems –Ch. 7
- Understanding Principles of Magnetism – Ch. 8
- Understanding the Principles of Electromagnetism – Ch. 9
- DC Generators and Motors – Ch. 10

Topic	Material	Hours
Substation Battery	Troubleshooting, setting up battery alarms, using test equipment, circuit board training	16

Lesson:

- **Substation DC Control System Overview** – Defines a battery and describes its purpose in a typical substation. Identifies the main components of a substation DC control system. Describes a basic DC control system arrangement. Describes the principles of operation for a typical DC control system.
- **Cell Components and Electrochemical Action** – Lists the basic components of a lead-acid cell. Describes the electrochemical action in a cell that is charging, and a cell that is discharging. Identifies specific physical indications of problems in a cell and explains their causes.
- **Cell and Battery Ratings** – Describes the voltage rating for a typical cell at full charge and at full discharge. Identifies the voltage for a given fully charged battery. Explains a cell's capacity rating. Identifies the capacity rating for a given fully charged battery. Defines specific gravity and identifies the specific gravity for a typical fully charged cell. Briefly describes the relationship of cell capacity, voltage, and specific gravity during discharge and during recharge.
- **Battery Inspection** – Lists the protective equipment and safety precautions typically associated with working on substation batteries. Describes typical visual battery inspection checks. Explains why it is important to keep good battery maintenance records. Describes a typical station battery report form.
- **Charger Functions and Components** – Describes the functions of a typical substation battery charger. Lists the common components of battery chargers and describe the function of each.
- **DC Control System** – Describes the layout of a typical DC control system. Describes the principles of how a DC control system works.
- **Freshening Charge** – Defines freshening charge and describes the basic steps for applying a freshening charge. Explains when a freshening charge is applied to a battery.
- **Float and Equalizing Charges** – Defines float charge and equalizing charge. Explains when each of the two charges is applied to a battery. Describes the basic steps for applying each of the two charges.

- **Charger Inspection and Adjustment** – Describes common charger inspection and adjustment steps

Topic	Material	Hours
Step Two Progression Test	Syllabus all materials gone over in months 13-17 (All of DC and batteries, workshop)	16

Lesson:

- Review and preparation for progression test.

Step 4 (Months 19 thru 24)
AC Theory Total Hours
Step 4 = 96

Topic	Material	Hours
DC schematics	Breaker schematics, Transformer schematics, Protection schematics	16

Lesson:

- *Understanding NV Energy control print for substation apparatus*

Topic	Material	Hours
AC Theory Level 1	AC theory courses 1 chapters 3-6, 8, 9 in the textbook and workbook	16

Lesson:

- Understanding Inductance and How It Affects a Circuit – Ch. 3 and 4
- Working with Inductors that are in Series and/or Parallel – Ch. 4 and 8
- Becoming Familiar with Inductive Reactance – Ch. 3
- Understanding Capacitance and How it Affects a Circuit – Ch. 5
- Understanding and Working Safely with Capacitors – Ch. 5
- Working with Capacitors that are in Series and/or Parallel – Ch. 6 and 9
- Becoming Familiar with Capacitive Reactance – Ch. 5

Topic	Material	Hours
AC Theory Level 2	AC theory courses 1 chapters 3-6, 8, 9 in the textbook and workbook	16

Lesson:

- Comprehending the Parameters of Series RL Circuits – Ch. 4
- Comprehending the Parameters of RC Circuits – Ch. 6
- Comprehending and Analyzing Series RLC Circuits – Ch. 7
- Understanding and Working with Parallel RL Circuits – Ch. 8

- Understanding and Working with Parallel RC Circuits – Ch. 9
- Comprehending and Analyzing Parallel RLC Circuits – Ch. 10
- Identifying and Working with LC Circuits – Ch. 7 and 10
- Comparing Series and Parallel RLC Circuits – Ch. 7 and 10
- Analyzing and Working with Combination RLC Circuits – Ch. 11

Topic	Material	Hours
AC Theory Level 3	AC theory courses 3 Repeat chapters 7, 10, Chapter 11, different book “test instruments and applications, Chapters 1-2, 13 textbook and workbook	16

Lesson:

- Power Factor – Ch. 11
- Power Factor Correction – Ch. 11
- General Use Test Instruments – Test Instruments and Applications Textbook Ch. 2
- Introduction to Generators – Ch. 1 and 2
- Understanding How the DC Generator Works – Ch. 13
- Understanding the Design and Function of AC Generators – Ch. 13

• Topic	Material	Hours
AC Theory chapter 14	AC theory chapter 14 with textbook and workbook	16

Lesson:

- AC Theory -Ch 14

Topic	Material	Hours
Step Two Progression Test	Syllabus all materials gone over in months 7-11 (Math 11-20, Knot tying rigging, Conduit Bending)	16

Lesson:

- Review and preparation for top out test.

Lesson: Using a Voltage Tester – States the main purpose of a voltage tester. Names the parts of a voltage tester and explains how a voltage tester works. Lists the steps required to check out a voltage tester and explains why it is necessary to check out a voltage tester before each use. Shows how to use a voltage tester.

Meter Principles – Lists the two general ways in which meters are classified. Describes the functions of a multimeter, a clamp-on ammeter, and a megohmmeter. Explains how a permanent magnet moving coil (PMMC) meter movement works.

Shows how a current measuring device can also be used to measure voltage and resistance.

Using a Multimeter, Part 1 – Identifies the switches, jacks, and scales on a typical multimeter. Demonstrates how to measure resistance and DC voltage using a multimeter.

Using a Multimeter, Part 2 – Demonstrates how a multimeter is used to measure DC current and AC voltage.

Using a Clamp-On Ammeter – Identifies the parts and features of a clamp-on ammeter. Explains how the scales on a clamp-on ammeter are read. Demonstrates how to use a clamp-on ammeter to measure current.

Using a Megohmmeter – Demonstrates how to operate a megohmmeter. Identifies some of the factors that affect how much resistance insulation has.

Lesson: Introduction to Circuit Breakers – Describes the main functions of a circuit breaker. Explains why arcs must be extinguished quickly. Describes the role of each of the following factors in extinguishing an arc in a circuit breaker: speed, distance, cooling, dielectric strength, zero current. Identifies four mediums commonly used in circuit breakers to help extinguish arcs.

Air-Magnetic and Air-Blast Circuit Breakers – Identifies the main arc extinguishing features of a typical air-magnetic circuit breaker. Explains how the arc extinguishing features in an air-magnetic circuit breaker work to extinguish arcs. Identifies the main arc extinguishing features of a typical air-blast circuit breaker. Describes how the arc extinguishing features in an air-blast circuit breaker work to extinguish arcs.

Oil and Vacuum Circuit Breakers – Identifies the main arc extinguishing features of a typical oil circuit breaker. Explains how the arc extinguishing features in an oil circuit breaker work to extinguish arcs. Identifies the main arc extinguishing features of a typical vacuum circuit breaker. Shows how the arc extinguishing features in a vacuum circuit breaker work to extinguish arcs.

Gas-Blast and Gas-Puffer Breakers – Identifies the main arc extinguishing features of a typical gas-blast circuit breaker. Explains how the arc extinguishing features in a gas-blast circuit breaker work to extinguish arcs. Identifies the main arc extinguishing features of a typical gas-puffer circuit breaker. Shows how the arc extinguishing features in a gas-puffer circuit breaker work to extinguish arcs.

Solenoid and Motor/Spring Operating Mechanisms – Identifies the main features of a typical solenoid circuit breaker operating mechanism. Explains how a solenoid operating mechanism works to operate a breaker. Identifies the main features of a typical motor/spring circuit breaker operating mechanism. Shows how a motor/spring operating mechanism works to operate a breaker.

Pneumatic and Hydraulic Operating Mechanisms – Identifies the main features of a typical pneumatic circuit breaker operating mechanism. Explains how a pneumatic

operating mechanism works to operate a breaker. Identifies the main features of a typical hydraulic circuit breaker operating mechanism. Shows how a hydraulic operating mechanism works to operate a breaker.

Lesson: General Circuit Breaker Maintenance – Describes routine circuit breaker status checks. Describes the purpose of isolating a breaker from its operating mechanism. Shows how to service circuit breaker components.

Operating Mechanism Maintenance, Part 1 – Describes general maintenance checks for circuit breaker operating mechanisms. Describes maintenance checks for solenoid and motor/spring operating mechanisms.

Operating Mechanism Maintenance, Part 2 – Describes maintenance checks for pneumatic and hydraulic operating mechanisms.

Air-Magnetic and Vacuum Breaker Maintenance – Describes maintenance tasks that apply specifically to air-magnetic breakers. Describes maintenance tasks that apply to vacuum breakers.

Oil Circuit Breaker Maintenance – Describes maintenance tasks specific to oil circuit breakers.

Gas-Blast and Air-Blast Breaker Maintenance – Describes maintenance tasks that apply specifically to gas-blast breakers. Describes maintenance tasks that apply to air-blast breakers.

Properties of SF6 – Describes the physical characteristics of SF6. Describes the effects of heat and moisture on SF6. Describes the potential hazards associated with SF6 and its decomposition products.

Personal Protection – Describes methods for minimizing the creation of SF6 decomposition products. Describes equipment that may protect personnel from exposure to SF6 and its decomposition products. Describes the treatment recommended for personnel exposed to SF6 or its decomposition products.

Handling SF6 Gas and its Decomposition Products – Describes the generally recommended procedures for removing SF6 gas and solid decomposition products from gas-insulated equipment during routine maintenance or access. Describes generally recommended procedures for removing SF6 gas and solid decomposition products after a fault.

Topic	Material	Hours
Circuit breakers print reading, ANSI device numbers	NV Energy Manufacturer's Schematics, Wiring Diagrams, Nameplates, and Assembly Drawings	16

Lesson: Students will be instructed on how to read NV Energy manufacture's schematics, wiring diagrams, nameplates and assembly drawings. Students will also review ANSI device numbers.

Topic	Material	Hours
Reclosers	Manufacturer's Instruction Books	16

Lesson: Students will be instructed on the operation of reclosers and their controls. Recloser classes will include all types of reclosers and controls used at NV Energy (North). Manufacturers' manuals and videos will be utilized for this training

Topic	Material	Hours
Circuit breaker test equipment	Manufacture's Instruction Books	16

Lesson: Students will learn the function and use of various circuit breaker test equipment. This will include motion analyzers, contact resistance meters, oil testers, trip profile testers, dew point testers.

Topic	Material	Hours
Knot Tying and Rigging	Rigging and Lift Principles NJATC Textbook and Workbook IBEW –Knot Tying and Rigging	16

Lesson: The student is introduced to the fundamental concepts involved in preparing and lifting loads and how to properly tie common knots used in the electrical trades.

Topic	Material	Hours
Step Four Progression Test	All materials used in months 19-24	5

Lesson: Preparation for Step 4 progression test.

Step 5 (Months 25 thru 30)
Transformers, voltage regulators
Total Hours Step 5 = 96

Topic	Material	Hours
Transformers, Level 1	NJATC course, textbook Chapters 1-2, 4-6	16

Lesson:

- Magnetism and Electromagnetism – Ch. 1
- Transformers Operation Principles – Ch. 2
- Transformer Connections – Ch. 4
- Real World Transformer Connections – Ch. 4
- Harmonics – Ch. 5
- Power Generation and Distribution – Ch. 6

Topic	Material	Hours
Transformers, Level 2, Doble DTA training, TTR, the Baron	NJATC course, textbook Chapters 7-8	16

Lesson:

- Reactors and Isolation Transformers – Ch. 7
- Autotransformers – Ch. 8
- Buck-Boost Transformers – Ch. 9
- Understanding Transformer Overcurrent Protection – Ch. 10
- Transformer Overcurrent Protection with Associated Tap Rules – Ch. 10
- Field Class training on Surge arrestors and SFRA

Topic	Material	Hours
Transformers, Level 3	NJATC course, textbook Chapters 3, 10-12	16

Lesson:

- Electrical Safety – Ch. 3
- Special Transformers – Ch. 10
- Special Connections – Ch. 11
- Selection and Installation – Ch. 12
- Maintenance and Troubleshooting – Ch. 13

Topic	Material	Hours
Regulators and LTCs	Siemens and Cooper, Reinhausen, Manufacturer drawings, factory rep, Hands-on training	16

Lesson: *Review drawings, regulator theory, regulator troubleshooting and repairs/maintenance. Regulator operation. Regulator controllers and settings. Review switching procedures.*

Lesson: Voltage Regulator Operation, Part 1 – Describes the function of a voltage regulator. Identifies the main components that enable an induction voltage regulator to adjust voltage.

Voltage Regulator Operation, Part 2 – Describes how a step voltage regulator adjusts voltage.

Voltage Regulator Control, Part 1 – Describes the function of a voltage detector and explains how it works. Describes the function of a line drop compensator and explains how it works.

Voltage Regulator Control, Part 2 – Describes the function of these components of a voltage regulator: time delay, limit switches, voltage reduction control, and first-house voltage protector.

Field Inspection – Describes common inspection steps typically performed on a voltage regulator.

Topic	Material	Hours
Transformer Print Reading	NVE manufacturer schematics, wiring diagrams, nameplates, and assembly drawings (need more material), schematics LTC and Regulators	16

Lesson: Review Transformer and LTC prints

Tap Changers – Explains what a tap changer is. States the function of a no-load tap changer and briefly describes how a typical no-load tap changer works. States the function of a load tap changer and briefly describes how a typical load tap changer works.

Tap Changer Maintenance – Identifies the steps for de-energizing, isolating, and grounding a power transformer. Lists the items typically included in a maintenance check of the physical condition of a load tap changer. Lists the items typically included in a maintenance check of the mechanical operation of a load tap changer. Lists the items typically included in a maintenance check of the electrical operation of a load tap changer.

Topic	Material	Hours
Step Two Progression Test	Syllabus all materials gone over in months 25-29 (All of transformers, drawings, ANSI device numbers, standards)	16

Lesson:

- Review and preparation for progression test.

Lesson: **Transformer Principles** – Lists the main parts of a transformer. Explains how a transformer fulfills the three requirements for electromagnetic induction. Describes the relationships between primary and secondary voltages and transformer turns ratio.

Power Transformers, Current Transformers, and Potential Transformers – Covers how to recognize and identify: power transformers, current transformers, and potential transformers.

Power Transformer Cooling Systems, Part 1 – Describes the purpose of power transformer cooling systems. Identifies a self-cooled power transformer and describes how the cooling system works. Identifies a self-cooled/forced-air-cooled power transformer and describes how the cooling system works.

Lesson: Power Transformer Cooling Systems, Part 2 – Identifies a forced-oil/forced-air-cooled power transformer and describes how the cooling system works. Describes the functions of temperature gauges and level gauges on a power transformer.

Power Transformer Sealing Systems, Part 1 – States the purpose of a power transformer sealing system. Identifies a gas-sealed power transformer and describes how the sealing system works. Identifies a conservator-type sealed power transformer and describes how the sealing system works.

Power Transformer Sealing Systems, Part 2 – Identifies a conservator-type sealed power transformer that has an air bag in the conservator and describes how the sealing system works. Identifies a gas/oil-sealed power transformer and describes how the sealing system works.

Visual Inspection – Lists the typical items checked during an inspection of a transformer's exterior condition, sealing system, and cooling system.

Gas and Oil Testing – Shows how to test: the gas in a power transformer for combustible gas, the gas in a power transformer for oxygen, and the insulating strength of the oil in a power transformer.

Tap Changers – Explains what a tap changer is. States the function of a no-load tap changer and briefly describes how a typical no-load tap changer works. States the function of a load tap changer and briefly describes how a typical load tap changer works.

Tap Changer Maintenance – Identifies the steps for de-energizing, isolating, and grounding a power transformer. Lists the items typically included in a maintenance check of the physical condition of a load tap changer. Lists the items typically included in a maintenance check of the mechanical operation of a load tap changer. Lists the items typically included in a maintenance check of the electrical operation of a load tap changer.

Turns Ratio Test – Explains how to test a transformer's turns ratio.

Insulation Resistance Test – Explains how to test a transformer's insulation resistance.

Lesson: Voltage Regulator Operation, Part 1 – Describes the function of a voltage regulator. Identifies the main components that enable an induction voltage regulator to adjust voltage.

Voltage Regulator Operation, Part 2 – Describes how a step voltage regulator adjusts voltage.

Voltage Regulator Control, Part 1 – Describes the function of a voltage detector and explains how it works. Describes the function of a line drop compensator and explains how it works.

Voltage Regulator Control, Part 2 – Describes the function of these components of a voltage regulator: time delay, limit switches, voltage reduction control, and first-house

voltage protector.

Field Inspection – Describes common inspection steps typically performed on a voltage regulator.

Field Control Checks – Describes control checks for a voltage regulator with solid-state control.

Regulator Replacement – Describes how to safely remove a voltage regulator from service, and how to safely put a voltage regulator back into service.

Capacitors, Reactors, Breakers & Reclosers Step 6 (Months 31 thru 36)
Total Hours for Step 6 = 96

Topic	Material	Hours
Capacitors and Reactors	Eaton, hands on, manufacturer training, drain a capacitor and cut it open, grounding capacitors, storing capacitors, safety, Chapter 5 from the AC theory, check NJATC courses	16

Lesson:

Lesson: Function of Capacitors and Reactors – Defines the following terms: working power, non-working power, capacitive power, inductive power, power factor, unity power factor. Describes how the relationship between working and non-working power determines the efficiency of the power produced in a T&D system. Explains how capacitor banks and shunt reactors are used to improve power factor.

Clearing Capacitor Banks – Describes how to safely de-energize, isolate, and test a substation capacitor bank. Describes how to safely ground a substation capacitor bank using portable grounds. Describes how to safely ground a substation capacitor bank that is equipped with switches.

Capacitor Bank Maintenance – Describes maintenance tasks commonly performed on substation capacitor banks. Identifies common problems to look for when inspecting substation capacitor banks. Describes how to safely remove individual capacitors and capacitor fuses. Describes special precautions required when handling capacitors containing PCBs.

Capacitor Resistor and Insulator Testing – Describes how to test the integrity of the internal resistance of a substation capacitor. Describes how to test the integrity of the insulators of a substation capacitor.

Capacitor Capacitance Testing – Describes several methods for checking the capacitance of substation capacitors. Describes how to check the balance of a substation capacitor bank.

Shunt Reactors – Identifies and describes two basic types of substation shunt reactors. Identifies common problems to look for when visually inspecting a substation oil- insulated shunt reactor and an air-core shunt reactor. Describes how to safely de- energize, isolate, test, and ground a substation shunt reactor. Describes how to test the insulation resistance of a substation shunt reactor.

Series Reactors – States the function of a substation series reactor and describes how a series reactor operates. Shows how to safely de-energize, isolate, test, and ground a substation series reactor. Identifies common problems to look for when visually inspecting a substation series reactor.

Topic	Material	Hours
Introduction to breakers and Air Breakers	Manufacturer books, Air breaker schematics, Hands on training, Testing	8

Lesson: Review safety and switching procedures for air breakers. Maintenance procedures and troubleshooting.

Introduction to Circuit Breakers – Describes the main functions of a circuit breaker. Explains why arcs must be extinguished quickly. Describes the role of each of the following factors in extinguishing an arc in a circuit breaker: speed, distance, cooling, dielectric strength, zero current. Identifies four mediums commonly used in circuit breakers to help extinguish arcs.

Air-Magnetic and Air-Blast Circuit Breakers – Identifies the main arc extinguishing features of a typical air-magnetic circuit breaker. Explains how the arc extinguishing features in an air-magnetic circuit breaker work to extinguish arcs. Identifies the main arc extinguishing features of a typical air-blast circuit breaker. Describes how the arc extinguishing features in an air-blast circuit breaker work to extinguish arcs.

Topic	Material	Hours
Vacuum Breakers	Hands on training RMAG, Hands on training metal clad vacuum breaker, Testing	16

Lesson: Maintenance and testing procedures for Vacuum breakers. Install and Troubleshooting

Oil and Vacuum Circuit Breakers – Identifies the main arc extinguishing features of a typical oil circuit breaker. Explains how the arc extinguishing features in an oil circuit breaker work to extinguish arcs. Identifies the main arc extinguishing features of a typical vacuum circuit breaker. Shows how the arc extinguishing features in a vacuum circuit breaker work to extinguish arcs.

Topic	Material	Hours
Oil Breakers	Manufacturer books, Oil breaker schematics, Hands on training, Testing	8

Lesson: Maintenance and testing procedures for Oil breakers. Troubleshooting

Oil and Vacuum Circuit Breakers – Identifies the main arc extinguishing features of a typical oil circuit breaker. Explains how the arc extinguishing features in an oil circuit breaker work to extinguish arcs. Identifies the main arc extinguishing features of a typical vacuum circuit breaker. Shows how the arc extinguishing features in a vacuum circuit breaker work to extinguish arcs.

Topic	Material	
Gas Breakers Circuit Switchers	Manufacturer books, Gas breaker schematics, Hands on training	24

Lesson: Maintenance and testing procedures for Gas breakers, review SF6 handling procedures, review safety procedures for handling faulted breakers and special procedures for faulted SF6 gas. Install procedures and troubleshooting.

Gas-Blast and Gas-Puffer Breakers – Identifies the main arc extinguishing features of a typical gas-blast circuit breaker. Explains how the arc extinguishing features in a gas-blast circuit breaker work to extinguish arcs. Identifies the main arc extinguishing features of a typical gas-puffer circuit breaker. Shows how the arc extinguishing features in a gas-puffer circuit breaker work to extinguish arcs.

- Understanding circuit switchers: their use, functions, maintenance and installation practices.

Topic	Material	Hours
Reclosers	Manufacturer books, Hands on training	8

Lesson: Recloser types and recloser controller types. Review testing procedures.

Topic	Material	Hours
Step Six Progression Test	Syllabus all materials gone over in months 31-35 (All of breakers, reclosers, capacitors, schematics)	16

Lesson: Review and prepare for progression test.

Step 7 (Months 37 thru 42)
Current Transformers, Potential Transformers,
System Protection, Relays & Switching Procedures
Total Hours for Step 7 = 96

Topic	Material	Hours
Current Transformers and Potential Transformers	NVE Prints, hands-on training, manufacturer drawings	8

Lesson:

CT Application and Construction – States the functions of a current transformer. Describes common current transformer applications in a substation. Describes the construction of common substation current transformers.

CT Accuracy Class and Operation – Explains the meanings of CT accuracy class ratings. Describes the basic operation of a current transformer. Explains saturation in a CT core. Describes a CT's turns ratio and current ratio as they relate to the CT's current and voltage output.

Polarity Testing: DC Kick Method – Explains why the polarity of a current transformer is checked. Describes the DC kick method of checking the polarity of a current transformer.

Polarity Testing: Current Method – Describes the current method of checking the polarity of a current transformer.

Demagnetizing a Current Transformer – Explains why it may be necessary to demagnetize a current transformer. Describes the basic steps for demagnetizing a current transformer.

Ratio Testing: Current Method – States the purpose of current transformer ratio testing. Describes the current method of checking the ratio of a current transformer.

Ratio Testing: Voltage Method – Describes the voltage method of checking the full winding ratio of a CT. Describes the voltage method of checking the tapped winding ratios of a CT.

Insulation Resistance Testing – Explains the purpose of testing current transformer insulation resistance. Describes the basic steps for testing the insulation resistance of a current transformer. Describes how to correct insulation resistance readings for temperature.

Topic	Material	Hours
System Protection and Monitoring	NVE Prints, hands-on training, manufacturer drawings	8

Lesson: Elements of System Protection and monitoring equipment Introduction –

Explains in general terms how system grounds, arresters, and fuses protect a T&D system. Briefly describes three types of monitoring and control equipment used in T&D systems.

System Grounds – Describes factors that affect the resistance of earth to current flow. Describes one method for installing a ground rod. Describes how substations, distribution systems, and transmission systems are typically grounded.

Arresters – Explains the principles of arrester operation. Describes the basic operation of a valve type arrester, a pellet type arrester, and an expulsion type arrester. Describes one method for replacing a damaged arrester.

Fuses and Fuse Cutouts – Describes the operation of an open-type fuse cutout and a door-type fuse cutout. Describes the operation of a fuse link. Explains how fuses are rated. Describes one method for replacing a fuse link in an open-type fuse cutout.

Topic	Material	Hours
Control Equipment	NVE Prints, hands-on training, manufacturer drawings	8

Lesson: Elements of substation control equipment

Monitoring and Control Systems – Describes the functions of a monitoring and control system. Describes some of the important features offered by most monitoring and control systems. Explains the functions of the major components in a SCADA

Distribution Automation and Load Management – Describes the functions of a distribution automation system and a load management system. Describes some of the important features offered by most distribution automation systems and load management systems. Explains in general terms how most distribution automation systems and load management systems operate. Describes the functions of the controllers in a distribution automation system and a load management system.

Control Functions, Modes, and Equipment – States two basic reasons why control is needed in a substation. Describes how control is provided. Identifies the equipment typically used to provide control.

Voltage Control – States why it is necessary to control voltage. Describes how a simple voltage control system works.

Distribution Feeder Fault Control – States why it is necessary to control the effects of faults. Describes how the effects of distribution feeder faults can be controlled using an overcurrent relay protective system and a feeder reclosing relay control system.

Transmission and Sub-Transmission Feeder Fault Control – Describes how the effects of feeder faults can be controlled using an impedance relay protective system. Identifies the difference between controlling the effects of feeder faults with an impedance system and controlling the effects of feeder faults with an overcurrent system.

Station Fault Control – Describes how the effects of station faults can be controlled using a differential relay system. Identifies the differences between controlling the effects of station faults with a differential system and controlling the effects of station faults with an overcurrent protective system.

Source Circuit Fault Control – Describes how the effects of source circuit faults can be controlled using a directional relay protective system. Describes how the effects of opens on a source circuit can be controlled using a voltage relay protective system. Describes how the duration of a source circuit outage can be minimized by an auto closing relay protective system.

Routine Checks of Control Equipment – Lists items typically checked during a routine inspection of substation control equipment. Identifies what various fault indications mean.

Topic	Material	Hours
Relays	NVE Prints, hands-on training, manufacturer drawings, Online course from Iowa State University (Homework)	24

Lesson:

- Overcurrent
- Directional
- Differential
- Distance
- Breaker Fail
- Comm Schemes
- CO Relay
- KD Relay
- SEL-351S (Breaker Fail)
- SEL-311C

Topic	Material	Hours
Telecom	SCADA, com aided protection	8

Lesson: Basics of Telecom Equipment, protection and system communication

Topic	Material	Hours
Protection Schematics	NVE Prints, hands-on training,	24

Lesson: In-depth lesson into reading and interpreting NVE protection schematics

Topic	Material	Hours
Step Seven Progression Test	Syllabus all materials gone over in months 31-35 (All of breakers, reclosers, capacitors, schematics)	16

Lesson: Preparation for progression test

Step 8 (Months 43 thru 48)

Cross training with System Protection, System Control, Troublemens

Preparation for Top Out Test

Approximate Total Program Hours 1,005

Wage

Wage Schedule for Apprentice Substation Electrician – See Collective Bargaining Agreement but should be reflected of prorated portions of the Journeyman Wage.