Credit: Enel

Guidelines for Wind Operations Qualified Electrical Workers

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AMERICAN CLEAN POWER

Introductory Information

Building, operating, and maintaining any power generation project requires a high level of electrical safety awareness, training, technical skills, knowledge, and the personal discipline to always act in a safe manner. Wind energy sites are unique in that there are so many tasks to be performed by so few technicians, often without the specializations found in traditional generation facilities. Electrical safety training is critical for all workers and managers, but each task on a wind site presents different hazards and mitigation procedures. Only those workers with the proven knowledge and skills for a task should be asked to perform that task, including the details of any electrical hazards that might arise and how to adequately safeguard themselves from those hazards. The purpose of this document is to develop a basic set of criteria for a Qualified Electrical Worker (QEW) program with suggestions for developing the training, managing the verification of skills and the implementation in the field including both the technical skills and the electrical safety elements to be considered. This is intended as a guideline to assist companies in preparing their own QEW program. Companies may consider this material in this guideline in accordance with their internal safety and other operating requirements as well as all applicable laws and regulations.

Wind technicians are expected to perform a wide variety of tasks, both mechanical and electrical, which can be very dangerous without proper training. Working at heights and in cramped conditions obviously complicate the situation. Additionally, they often work without direct supervision, so it is critical that skills be taught, and competency verified before the technician is considered qualified to perform the task alone. It is also critical that a culture of personal responsibility and a high level of conformance to procedures is nurtured as a part of the overall operational management strategy. Technicians can only be expected to remain safe if they clearly understand the risk associated with given tasks and are self-motivated to avoid unnecessary risk to themselves or others.

The guidelines and suggestions in this document may prove useful for both construction and maintenance technician. Although various agency requirements may apply, the focus will be primarily on operations and maintenance personnel as most construction tasks are performed before the site is energized and the general safety requirements for construction are well documented. Acceptance testing and commissioning technicians typically face the same challenges as the O&M staff and should be qualified appropriately.

Table of Contents

Scope and Purpose

Scope: This document provides guidance for the development of a wind energy industry Qualified Electrical Worker (QEW) program.

This program will define the minimum knowledge and technical abilities required to attain proficiency as a qualified person(s) permitted to work on or near exposed energized parts. Person(s) who successfully complete the program will be able to demonstrate skills and knowledge in construction and operation of electrical equipment and installations, and the hazards involved. The program will ensure that personnel trained as a QEW will meet compliance with Occupational Safety and Health Administration (OSHA) Code of Federal Regulations (CFR) Subpart S 1910, the current edition of the National Fire Protection Association (NFPA) 70E, and other regulations and standards required to work in the United States wind energy industry.

Purpose: Establish recommendations for a QEW program for member companies and original equipment manufacturers (OEMs) who may adapt these recommendations to their own platform specific requirements.

Program Development Suggestions

A comprehensive qualification program should include, at an appropriate level, elements of classroom, self-study, and performance verification on the following skill sets:

Electrical principals

- Fundamentals of matter, energy, and electricity
- Direct current (DC) fundamentals, including:
    - Ohm's Law and calculating voltage, current, resistance and power in the DC systems
- Battery theory and operation
- Alternating current (AC) fundamentals, including application of Ohm's and Kirchoff's Laws to single- and three-phase circuits
- How AC is generated
- Inductance, capacitance, and reactance
- How transformers work
- Grounding and bonding (insulation, isolation, and equipotential grounding)

Basic electrical skills

- Use of electrical test equipment and meters
- Interpretation of nameplates and data plates of common electrical devices
- Operation of disconnect switches and circuit breakers
- Explanation and use of overcurrent protective devices, molded- case circuit breakers, insulated-case circuit breakers and low-voltage power circuit breakers
- Troubleshoot electrical control and power circuits
- Interpretation of electrical drawings and prints, including:
    - Single-line diagrams
    - Three-line diagrams
    - Ladder diagrams
    - Schematics
- Use of voltage testers, megohmmeters and micro-ohmmeters

Troubleshooting

- Types of electrical system drawings, layout, and the purpose of drawing type
- Interpretation of legends used on electrical drawings and schematics
- Identify and interpreting electrical symbols
- Standard American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE) device numbers
- How circuits and devices interact with each other
- To understand the "logic" functions in control systems
- To troubleshoot electrical problems using diagrams, one-line diagrams and schematics
- Use of electrical test equipment to determine energized equipment and hazards associated with troubleshooting installed equipment

Operation of wind projects

- Types and classes of turbines
- Wind project components and layouts
- Key maintenance and operations performance indicators

- Supervisory Contral and Data Acquisition (SCADA) basics
- Grid reliability requirements (North American Electric Reliability Corporation (NERC)/Federal Energy Regulatory Commission (FERC))
- Shutdown and isolation of wind energy generators
- Switching and lockout/tagout (LOTO) considerations

Turbine operation

- Safety-related tasks
- Platform specific design issues
- Electrically related tasks per platform requirements
- Generator and convertor maintenance requirements
- Operational on-board electrical components including UPS, pitch/yaw motors and drives, LV lighting and power supplies, control slip-ring maintenance, gearbox auxiliary components, etc.

Collections systems

- Pad mount transformer maintenance, testing, switching, and operation
- Medium-voltage and high-voltage cable and accessories
- Switchgear and other collection point devices
- Grounding systems and transformers
- Effects and prevention of transient voltages, including lightning, power surges and harmonics

Substation Basics

- Overview of substation design and operation
- Medium-voltage components and systems
- High-voltage components and systems
- Capacitor banks and switching
- Other power factor correction devices and calculations
- Protection and Control basics
- Communications systems requirements
- Main transformer basics including bushings, components and auxiliary devices
- Battery maintenance and safety

Definitions

Accepted. An installation that has been inspected and found by a nationally recognized testing laboratory to conform to specified plans or to procedures of applicable codes.

Conductor. A material capable of carrying electrical current. When used in electrical circuits the material is usually in the form of a wire, cable, or bus bar.

1. Bare. A conductor having no covering or electrical insulation whatsoever.
2. Covered. A conductor encased within material of composition or thickness that is not recognized as electrical insulation.
3. Insulated. A conductor encased within material of composition and thickness that is recognized as electrical insulation.

De-energized. An electrically safe work condition. Per NFPA 70E Article 100, an electrically safe work condition is a state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to verify the absence of voltage, and, if necessary, temporarily grounded for personnel protection.

Device. A unit of an electrical system that is intended to carry but not utilize electric energy.

Enclosed. Surrounded by a case, housing, fence, or walls that will prevent persons from accidentally contacting energized parts.

Energized. Electrically connected to a source of potential difference.

Equipment. A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of, or in connection with, an electrical installation.

Ground. A conducting connection, whether intentional or accidental, between an electric circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Insulated. Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

Listed. Equipment is "listed" if it is of a kind mentioned in a list that:

1. Is published by a nationally recognized laboratory that makes periodic inspection of the production of such equipment, and
4. States that such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner.

Overcurrent. Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.

Qualified person. One who has received training in and has demonstrated skills and knowledge in the construction and operation of electric equipment and installations and the hazards involved.

- Note 1 to the definition of "qualified person:" The employer may consider and employee qualified for some work scopes but unqualified for others.
- Note 2 to the definition of "qualified person:" An employee who the employer deems competent to participate in on-the-job training and conducts that training under the direct supervision of a qualified person is considered a qualified person for the performance of those duties.

Service. The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

Switch.

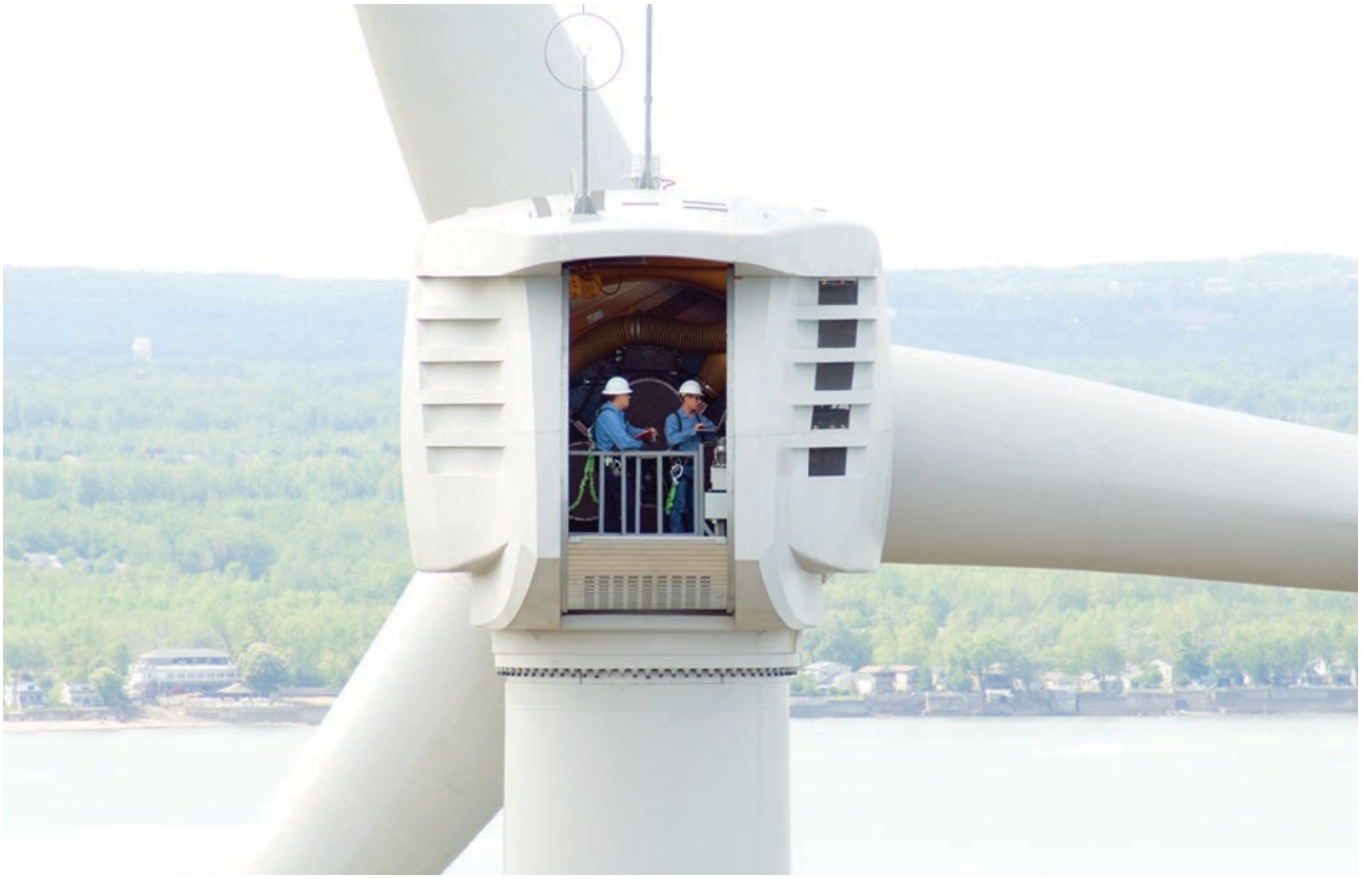
1. General-use switch. A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.
2. General-use snap switch. A form of general-use switch constructed so that it can be installed in device boxes or on box covers, or otherwise used in conjunction with wiring systems.

Voltage (of a circuit). The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned.

Voltage, nominal. A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240 volts, 480Y/277 volts, 600 volts). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

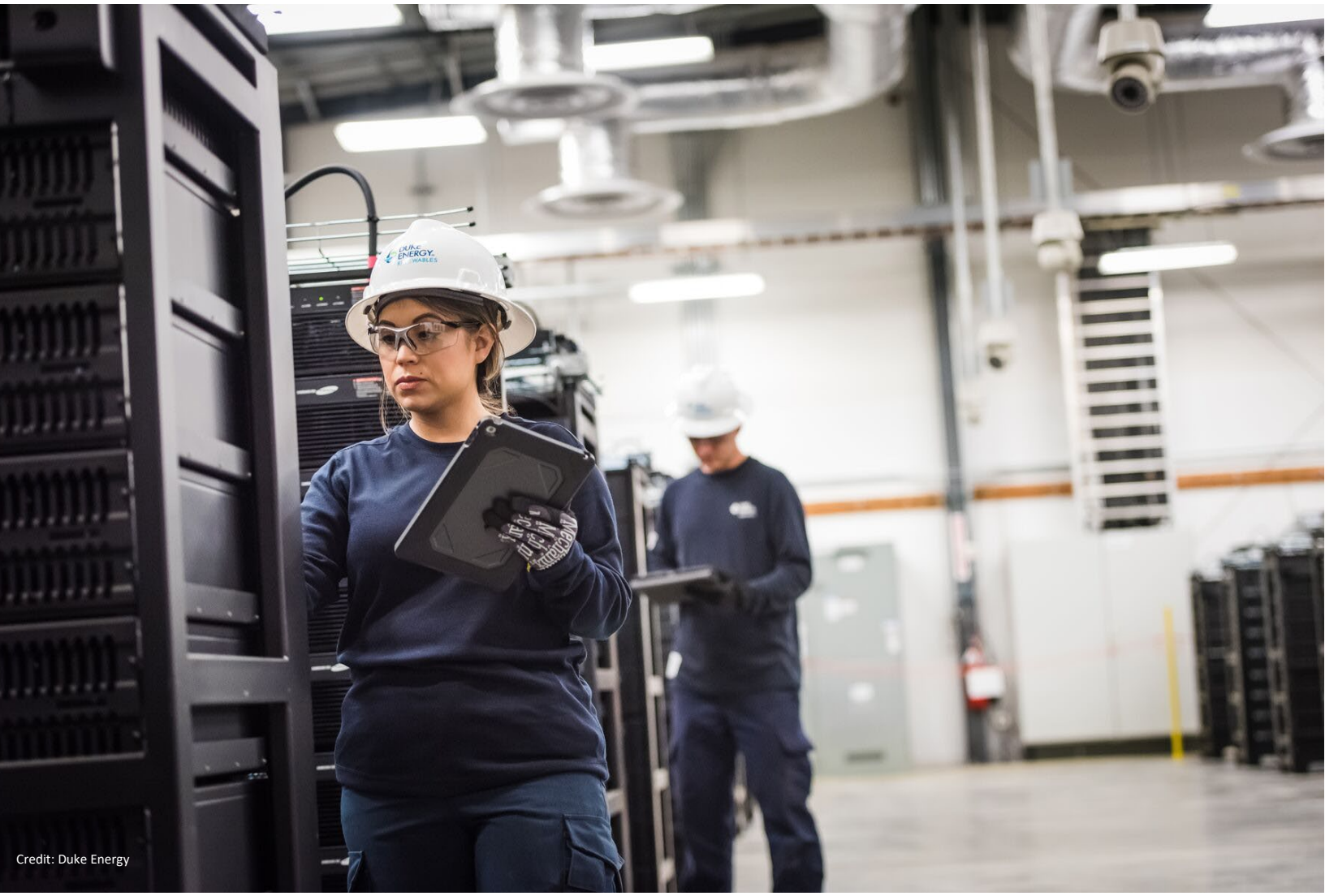
Voltage to ground. For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Weatherproof. So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, raintight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.



References—applicable standards

A. National Training Laboratories, Bethel ME.
B. NFPA70E, Standard for Electrical Safety in the Workplace, 2021 edition or its successor.
C. OSHA 29 CFR 1910 Subpart S, including 29 CFR 1910.332.
D. Guidelines for Qualified and Unqualified Electrical Workers ©2013 American Wind Energy Association.
E. Best Practices for Wind Power Facility, Electrical Safety October ©2018 CanWEA or its successor.
F. NETA/ANSI MTS Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems, 2019 edition or its successor.
G. NFPA 70B, Recommended Practice for Electrical Equipment Maintenance, 2019 edition or its successor.
H. NFPA 70, National Electric Code
I. OSHA 1910.269 (a)(2)(i-viii) Electric power generation, transmission, and distribution



Credit: Duke Energy

Qualified Workers

A person designated by the employer as competent to complete electrical work within a defined work scope and can identify and control the hazards associated with that scope of work.

A. Skills Required and Safety Requirements

Each qualified employee should also be trained and competent in:

1. Techniques to distinguish exposed energized conductors and circuit parts from other parts of electrical equipment.
2. Techniques to determine the nominal voltage of exposed energized conductors and circuit parts.
3. Minimum approach distances specified in this section associated with the nominal voltages of exposed conductors and methods needed to maintain those distances.
4. Identification of limited, restricted, and arc flash boundaries.
5. Use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools when working on or exposed to energized parts of electrical equipment, and identification of electrical hazards and methods to control or eliminate these hazards.
6. Selection, operation, and limitations of test instruments.
7. Methods of verifying zero energy in electrical circuits or circuit parts.
8. Creation of an electrically safe work condition.
9. Development of job safety plans.
10. Assessment of risk of arc flash and electrical shock associated with the assigned task.
11. Selection of electric shock and arc flash personal protective equipment (PPE)

B. Unqualified Persons

1. Unqualified Persons. Basic Level workers (unqualified electrical workers) should be trained in, and be familiar with, electrical safety-related practices necessary to address electrical hazards they may encounter as part of their normal work activities. See Appendix A for additional details.

Electrical Safety training

1. The employer should determine through supervision and periodic inspections that employees are complying with the safety-related work practices recommended by this guideline.
2. Type of Training. The training should be classroom, on-the-job, or a combination of the two. The type and extent of the training provided should be determined by the risk to the employee.
    a. Training can be augmented by digital delivery platforms, but attendees of re-training must have the ability to ask questions and have them answered immediately. Re-training occurs after an incident and an individual needs to get trained again.
3. Refresher training in safety-related work practices and applicable changes in this guideline should be performed at intervals not to exceed three years.
4. An employee should receive additional training (or retraining) for any of the following conditions:
    a. The supervision or annual inspections indicate the employee is not complying with the safety-related work practices.
    b. New technology, new types of equipment, or changes in procedures necessitate the use of safety-related work practices different from those that the employee would normally use.
    c. The employee needs to review tasks that are performed less than once per year.
    d. The employee needs to review safety-related work practices not normally used by the employee during regular job duties.
    e. The employee's job duties change.

5. Recommend providing qualified electrical workers with contact release training.
6. Electrical Safety Training Documentation. The employer should document that each employee has received the training. This documentation should be in accordance with the following:
    a. Made when the employee demonstrates proficiency in the work practices involved.
    b. Be retained for the duration of the employee's employment.
    c. Contain the content of the training, each employee's name, and dates of training and the name of the trainer.
    d. All training documentation will be retained in accordance with the company records management system.

C. Practical Competency Assessments for Qualified Electrical Workers

A qualified instructor should verify:

1. Multimeter and other electrical meter use: demonstrate the correct use of the specific instrument(s), including:
    - Pre- and post-use meter inspection,
    - Limitations of meters,
    - Selection of appropriate meter settings, and,
    - Performance of required measurements.

    Note: Training on specific types of instruments can often be obtained from the instrument ` manufacturer.

2. PPE for a defined work task:
    - Required PPE selection and use,
    - Identification of voltage-rated gloves,
    - Inspection of voltage-rated gloves,
    - Use of voltage-rated gloves,
    - Determination of when and what arc-rated PPE is required,
    - Inspection of arc-rated PPE,
    - Storage of electrical arc-rated and shock PPE,
    - Proper selection of head, neck, and face protection, and,
    - Other similar decisions.

3. Interpreting key information on arc flash labels in accordance with NFPA 70E:
    - Demonstrate and explain the information and layout of the label.
    - Determine and select required PPE from the label or arc flash study.
    - What the working distance on a label or arc flash study means to the individual.
    - Determine restricted and limited approach boundaries.

4. Electrical Switch or Circuit Breaker Operation:
    - Describe the mechanical working of a switch or circuit breaker and operation.
    - Where to stand, which way to look, what hand to use for operation.
    - What PPE to wear.
    - Methods to reduce the risk involved in circuit breaker/switch operation.
    - Best practice: Why holding one's breath during operation is important.
    - Ways to verify breaker is in the Closed, Open or Grounded position.
    - Emergency procedures in the event of an electrical incident.
    - Verification of Zero Energy State: Verify the correct equipment, component, and device.
    - Visual verification of the contacts/blades of the disconnect being open, proper setup of boundaries for shock and arc flash protection for unqualified personnel.

- Before-and-after multimeter operation verification.
- Verification that all terminals within the circuit are at zero energy state, both phase-to-phase and phase to ground.
- Confirmation of “ghost” voltages and back feeds that may be possible.

Credit: Invenergy

Suggested levels of competence for wind energy technicians

Level 0 Basic Skills

(Level 0 is chosen so the new employee recognizes their relative position and wants to move up in levels. It is recommended that a special hard hat sticker or identifying patch be used to alert other workers of that status.)

1. Entry level. A high school graduate or equivalent. Preferably a technical college graduate.
2. Unqualified to perform electrical tasks in the field unsupervised by a QEW. Might be qualified for mechanical tasks not requiring electrical isolation or exposure.
3. Completed training for worksite safety, basic electrical safety, construction safety, operation of the generators and operation of the wind site.
4. Completed training for basic electrical theory, electrical equipment operation and electrical safety procedures.
5. Limited to low voltage circuits while under supervision by a QEW.

Minimum Competencies Level 0

Core Competencies — Level 0 Basic Skills

Electrical safety program, policies, procedures, and emergency response
Recognize electrical hazards
Purpose and limitations of hazard and warning signs and barriers
Trained to recognize and participate in LOTO
Use and application of PPE
Worksite safety
Basic electrical safety
Generator operation
Understand the proper use and importance of ground-fault circuit interrupters (GFCIs)
Be able to perform light maintenance tasks, such as changing light bulbs
Understand how electrical hazards affect the body

Level 1 Qualified Electrical Worker

1. Be qualified Level 0.
2. Be able to perform most in-turbine tasks without direct supervision.
3. Have a comprehensive knowledge of turbine schematics and lockout/tagout procedures.
4. Has demonstrated ability to perform electrical troubleshooting.
5. Tasks are typically limited to 1000V and below circuits.
6. Possess a comprehensive knowledge of electrical safety, PPE selection and arc flash and shock hazards.
7. Must demonstrate skills to perform any specific task.
    a. Once that task is demonstrated successfully, they are allowed to perform it unsupervised.
8. Training would include OSHA regulations associate with electrical, NFPA 70E requirements, site-specific safety procedures, site-specific equipment training, basic human performance, tower rescue procedures, Absence-of-Voltage testing, inspection, use and limitations of basic electrical test equipment, such as Volt-Ohm-Meter, insulation resistance, etc.

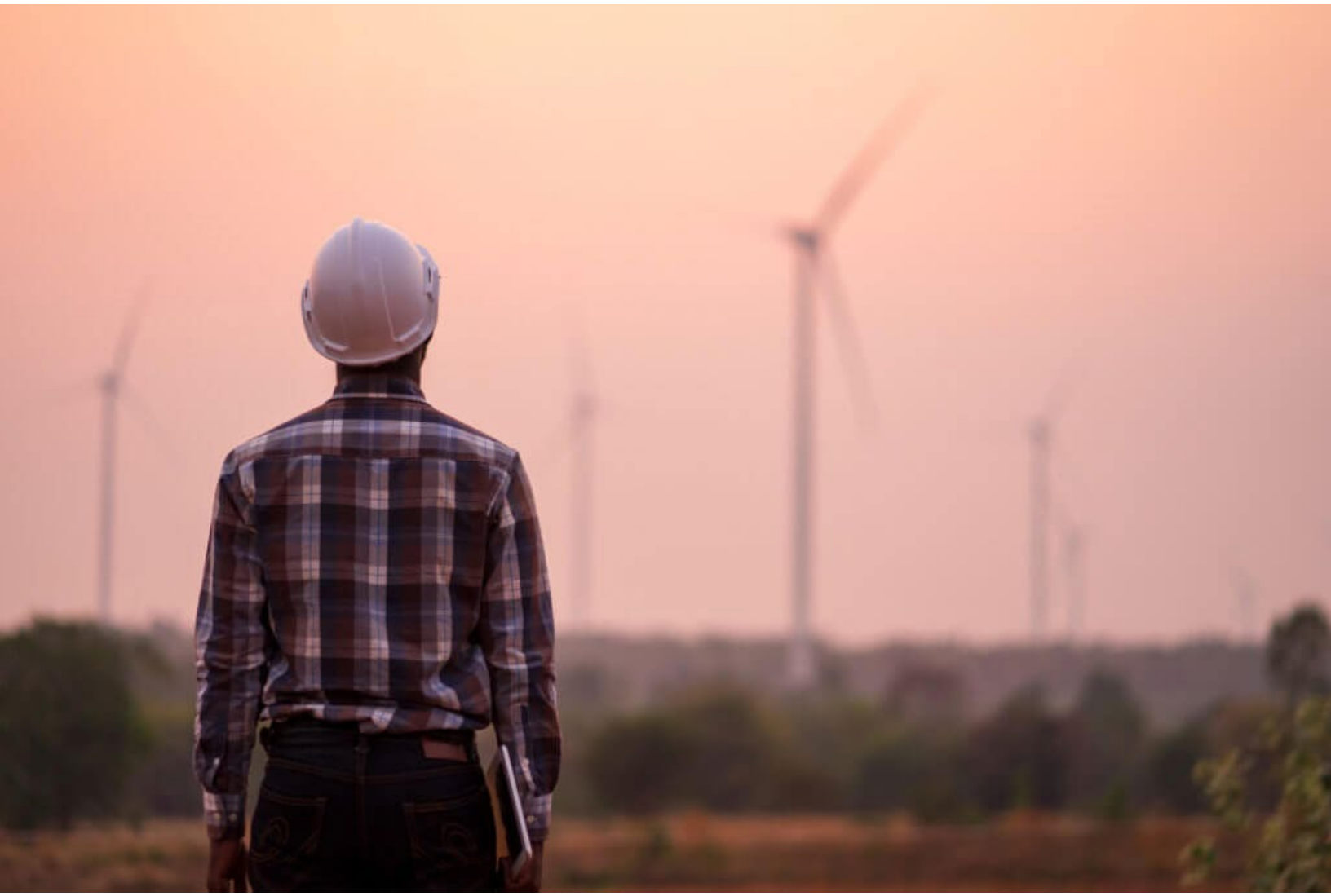
Minimum Competencies Level 1

Core Competencies — Level 1 Qualified Electrical Worker

(Plus all Level 0 Competencies)

Be able to perform low-voltage absence-of-voltage testing techniques
Be able to use basic electrical test equipment, such as VOM, insulation resistance
Be able to use and apply low-voltage testing equipment properly:
1. Inspections
2. Indications
3. Limitation of use
Be able to place low-voltage equipment in an electrically safe work condition
Perform basic lockout/tagout procedures supervised by a QEW
Select, inspect, maintain, store, and use PPE
Determination of the limited and restricted approach boundaries
Determination of the arc flash boundary
Select required arc flash PPE and demonstration of arc-flash reduction procedures
Ability to implement site-specific safety procedures
Operation of site-specific equipment
Demonstrate absence-of-voltage testing techniques
Identify typical electrical hazards found on company facilities
Identify the degree of hazard (shock, arc flash and arc blast)
Understand how to minimize risk by using proper body position
Techniques used to perform a risk assessment

Clearance requirements around equipment
Application of safety barriers and signs
Operation of low-voltage electrical power system equipment
Inspection low-voltage equipment to determine its condition of maintenance
Inspection of low-voltage control circuits and components



Level 2 Qualified Electrical Worker

1. Qualified Level 1.
2. Advanced troubleshooting, including electrically live devices.
3. Able to perform lockout/tagout in accordance with developed procedures and release for troubleshooting.
4. Demonstrated the ability to execute work instructions for electrical and mechanical repair of on-site equipment.
5. Restricted to in-turbine work, up to load side of breakers or disconnects supplied MV transformers.
6. Operate and maintain of wind generator equipment.
7. Application of low-voltage test equipment, including pre- and post-use inspections, connection of test instruments and interpretation of test results.
8. Serve as lead for two person crews performing electrical work.
9. When supervised by a Level 3 or higher perform work on circuit above 1000 V.
   Qualified to use other types of test equipment at the wind site as required by supervision.

Minimum Competencies Level 2

Core Competencies — Level 2 Qualified Electrical Worker

(Plus all Level 0 & 1 Competencies)

Inspect electrical power system equipment to determine its condition of maintenance
Test and inspect low-voltage cables
Assist in the inspection of substation equipment
Use high/low-voltage electrical testers and understand their limitations
Troubleshoot, isolate, and perform maintenance on wind generators, their controls and related equipment
Purpose and application of temporary protective grounds
Test temporary protective grounds
Assist in the use of and application of high-voltage testing equipment properly:
1. Inspections
2. Indications
3. Interpretation of test results

Level 3 Qualified Electrical Worker >1000VAC

1. Meet qualifications for Level 2.
2. Perform Balance of Plant (BOP) tasks including switching, transformer testing and cable testing.
3. Demonstrate knowledge of arc flash hazards on BOP devices.
4. Isolate BOP electrical devices.
5. Perform low risk substation tasks such as battery testing and general maintenance within the fence.
6. Operate and maintain wind site equipment.
7. Testing safety and procedures using higher voltage equipment

Minimum Competencies Level 3

Core Competencies — Level 3 Qualified Electrical Worker

(Plus all Level 0, 1, & 2 Competencies)

Use and application of energized electrical work permits
Ability to conduct electrical shock and arc flash risk assessments
Use of high-voltage test equipment
Create electrically safe work conditions for high-voltage equipment
Be able to perform complex lockout/tagout procedures
Be able to apply safety barriers and signage
Be able to operate high-voltage equipment, such as circuit breakers and switches
Be able to complete a routine energized electrical work permit for signature
Be able to inspect electrical power system equipment to evaluate its condition
Be able to troubleshoot both high- and low-voltage equipment
Be able to perform ground system testing and evaluation
Understand the purpose and importance of ground system maintenance
Be able to perform common maintenance tasks on wind generating equipment
Supervision and Human Performance training certification suggested

Field Supervisor Level (Electrical Site Manager)

1. Be qualified Level 3.
2. Fully understand hazards and the risk associated with working with electricity.
3. Can either perform required training for workers or can secure it through a third party.
4. Suggested management level human performance training, as well as training on implementing OSHA 29CFR 1910.269, NFPA 70E, and site-specific safety training.

Minimum Competencies Supervisor Level

Core Competencies — Field Supervisor

Understand the Energized Electrical Work Permit and hierarchy of control methods
Understand the PPE program, their roles, and responsibilities
Understand PPE inspection, selection, training and use for their employees
Perform and review risk assessments
Understand the difference between qualified and unqualified personnel and the responsibilities of each
Understand lockout/tagout procedures and the requirement for annual audits
Understand their enforcement role for the electrical safety program
Understand their responsibility for developing basic rescue procedures
Understand the safety network structure at company facilities
Understand clearance requirements around equipment
Understand the basic theory behind conducting an arc flash hazard analysis

Common tasks by skill level

Wind project tasks are generally divided into three areas: wind turbines, generating systems, collection systems and substations. Within each of these areas are tasks appropriate for the various skill levels of technicians, so definitions of the needed qualifications should be clear to both the individual technician and their supervisor.

Here are some examples of electrical maintenance areas:

Up-Tower Wind Turbine Generation Equipment

- Generators/Power slip rings
- Pitch and yaw motors and controls
- Control panels/inverters
- Control slip rings
- Batteries (UPS and DC Controls)
- Several types of transformers

Down-tower Equipment

- Inverters
- Turbine grounding systems
- Isolation switches
- Switch gear

External apparatus and collection network

- Pad mount transformers
- Underground collections system
- Utility Poles

Substation components, transformers, protective relays, pole-mounted equipment, and circuit breakers

Specialized electrical test equipment

Below are charts with common task areas for various skill levels. In each case, comprehensive training sections should be developed based on the site-specific equipment and safety requirements. This training should include the technical task, the hazards and safety aspects of the task and a process to demonstrate competency to an appropriate level for review and recorded acknowledgement pf that competency.

Level 0 Basic Skills

Assist with mechanical and de-energized electrical tasks
Perform simple lockout/tagout procedures
Operate low-voltage controls as required
Operate lifts, winches, and other auxiliary devices
Be able to use low-voltage power tools as required
Assist and document inspections on low-voltage equipment

Level 1 Qualified Electrical Worker

(Plus all Level 0 Tasks)

Collector grid maintenance
Ground grid maintenance
Be able to operate low-voltage circuit breakers and switchgear
Be able to perform low-voltage cubicle inspections
Be able to perform low voltage Pad Mount and Grounding Transformer Tests:
1. Transformer turns ratio (TTR) Test
2. Winding Resistance Test
3. Insulation Resistance Test
4. Thermal Imaging
Taking Oil Samples
Inspecting pad mount transformer foundation
Inspecting secondary cable systems
Testing fiber optic cables
Infrared Testing of Power Cable Connections
Inspection of Surge Arresters
Infrared Testing of Surge Arresters
Understand simple and complex lockout/tagout procedures
Operate low-voltage electrical power system equipment, such as switches and circuit breakers
Understand how to inspect low-voltage equipment to determine its condition of maintenance

Level 2 Qualified Electrical Worker

(Plus all Level 0 & 1 Tasks)

Take readings on substation class transformers
Visually inspect transformer bushings
Assist in the visual inspection of outdoor substation equipment
Inspect and maintain substation fences and gates
Check alarm circuits
Perform tests for continuity and voltage on fans
Check heat exchangers
Testing and application of temporary protective grounds
Assist in testing and inspection of high-voltage cables for learning
Inspection requirements of substation equipment
Assist with the use of high-voltage test equipment for learning
Assist in operating high-voltage electrical power system equipment for learning
Perform insulation resistance test on secondary cable systems

Level 3 Qualified Electrical Worker > 1000VAC

(Plus all Level 0, 1, & 2 Tasks)

Rack in medium-voltage circuit breakers
Rack out medium-voltage circuit breakers
Circuit breaker tests:
1. Contact resistance
2. Insulation resistance
3. Insulation power factor
4. Vacuum bottle tests, such as integrity and remaining life
Power Transformer Tasks
1. Sampling oil from power transformer
2. Perform dielectric test on oil
3. Perform insulation power factor test
4. Perform required inspections before re-energizing
5. Re-energize transformer

6. Filter the transformer insulating liquid
Perform insulation resistance test on station surge arresters
Perform insulation power factor on station surge arresters
Test inter-cell resistance of battery banks
Test internal impedance/conductance on battery banks
Test and verify battery charger output and operation
Verify negative terminal temperature (VRLA Batteries Only)
Verify AC charger ripple voltage/current (VRLA Batteries Only)
Perform Maintenance on Batteries:
1. Physical inspection
2. Check room temperature
3. Verify room ventilation
4. Verify electrolyte levels
5. Verify float voltage
6. Verify output voltage
Monitor protective relay alarm via SCADA
Monitor for potential protective relay failures not detected by SCADA
Inspect generator lead line
Maintain transmission line clearances
Perform insulation resistance test on secondary cable systems
Perform inspection of medium-voltage cable systems:
1. Perform visual inspection
2. Perform conductor phasing test
3. Perform conductor resistance/continuity test on neutral wires
4. Perform off-line PD test
5. Perform insulation resistance test or VLF test
6. Perform infrared tests of accessories

Appendix A. Unqualified Electrical Worker Guidelines

Training (Unqualified Electrical Worker)

This category includes all management and support staff that are performing non-electrical tasks near electrical equipment, regardless of its energized state. All unqualified personnel should remain outside of the limited approach boundary of any exposed circuits and circuit parts energized above 50 volts unless under the direct supervision of a QEW. All unqualified personnel should be trained in and familiar with the following information:

- Minimum approach distance for the various voltages present at their plant.
- Not to cross the limited approach boundary, unless continuously supervised by a QEW.
- The risk associated with energized equipment.
- The tasks that can only be performed by QEWs.
- How to protect themselves when working around electricity.
- The importance of obeying electrical hazard signs and tags.
- Who to report electrical hazards to after they have been identified.

Sample training guide for Unqualified Workers

1. In order for an unqualified person to recognize and avoid hazards, it will be important that they understand the basics of electricity including:
    - Voltage.
    - Amperage.
    - Resistance.
    - How to read and comply with Arc Flash Hazard Analysis Labels.
    - Using nameplate data to determine the Limited Approach Boundary.
    - Devices that store energy after they have been de energized.
    - Job briefing requirements.
2. The more common electrical hazards the unqualified personnel might encounter.
3. The common types of electrical injuries *Be able to describe specific electrical hazards at your facility.*
4. The unqualified personnel need to know how electrical shock occurs and how the severity of the electrical shock is determined.
5. Typical electrical accidents explained involving “Arc Flash”, “Arc Blast”, and Electrical Burns.
6. Discuss ways to avoid electrical shock.
    - Do not touch covered or insulated conductors.
    - Do not open electrical cabinets or panels.
    - The risk involved when jewelry is work, even in the office space.
7. Damaged equipment can result in serious electrical hazards. Describe the facility’s policies on damaged equipment and the procedures for reporting damaged.
8. The purpose and use of Ground Fault Circuit Interrupters (GFCI)
9. Lockout/Tagout procedures at the facility. The importance of placing electrical equipment in an electrically safe work condition to prevent an electrical shock. Basic ability to recognize Lockout/Tagout equipment.
10. Describe/ and review safe work practices and procedures at the facility. Show trainees a copy of any written safe work practices adopted by the company related to electrical safety.
11. Emphasis that the training received does not mean the attendees are qualified to perform any electrical task.

Appendix B. Human Performance Guidelines

Personal responsibility and human performance factors are critical to any organizational success. This has become a core component of many electrical safety programs as well as for quality management initiatives and workforce development criteria. QEWs in the wind energy sector often work in small groups without direct supervision. Personal integrity to properly performing tasks in a safe manner must be part of the workplace culture all day, every day.

The HOP Hub (http://www.hophub.org) addresses some of the organizational, leadership and worker responsibilities that are necessary for establishing and maintaining a high level of safe behavior in high-risk industries. A culture that is truly organized around safe behavior reduces the risk created by human error and contributes to the prevention or mitigation of damages in case of an incident.

The HOP Hub has materials to assist in the development of a human performance program in conjunction with implementing a QEW process.

The NFPA 70E Informative Annex Q lists the five basic principles of human performance:

1. People are fallible and even the best people make mistakes.
2. Error-likely situations are predictable, manageable, and preventable.
3. Individual performance is influenced by organizational processes and values.
4. People achieve high levels of performance largely because of the encouragement and reinforcement received from leaders, peers, and subordinates.
5. Incidents can be avoided through an understanding of the reasons that mistakes occur, and applications of the lessons learned from past mistakes.

In implementing a strong QEW program for the wind industry, human performance tools should be available to all workers and managers. These would include safety and job skills briefings before a task is undertaken, clear procedure adherence guidelines, clear three-way communication channels and safety or technical stop-work authorization.

For more information on developing and implementing an effective human performance program, see these references, among other sources.

Appendix C. Other Training Considerations

Task	• Objectives
Personal Protection Equipment (PPE)	• What is a caught-in or -between hazard • Types of caught-in or -between hazards • What PPE is • Why PPE is used • Types of PPE to use • How to care for PPE • Required PPE in the industries
Health Hazards in Construction and **Hazardous Materials**	• Explain what "the right to know" is • List various types of PPE used to handle hazardous materials • Describe basic first aid requirements for exposure to hazardous materials • Describe what spills and leaks are • Define what labels and SDSs are and the importance of their use • Define LOTO (Lockout Tagout) • Define a confined space • Define to categories of respirators
Materials Handling	• What is material handling? • Material handling hazards • Proper lifting of materials • How to avoid material hazards
Tools	• When to inspect tools • Appropriate types of PPE to use with tools • When to use guards • Proper storage of tools • Safe handling techniques for hand and power tools
Excavations	• Excavation hazards and risks. • Proper protective systems. • Who inspects? • Proper base and backfill required for underground cable
ARI Signalperson certificate (5 years)	• Identify basic crane terminology and definitions • Explain boom deflection, center of gravity, and how to compensate for it • Identify the hazards and safety concerns associated with overhead lifting • Recognize and apply the applicable OSHA and ASME standards. • Demonstrate hand signals per ASME B30.5 and B30.3. • Demonstrate voice communication • Explain the pre-lift planning process
Crane Rigging **ARI Level 1 Rigging certificate** (5 years)	• Define responsibilities and safety rules for rigging and hoisting loads • Inspect, select, maintain, and reject rigging equipment and hardware • Identify rigging hardware and slings along with defining their limitations • Identify load ratings, safety factors, and stresses imposed by hoisting • Calculate material load weights • Identify capacities of rigging and attach the appropriate rigging

Authorized Climber and Rescue Certification (2 Years)	• Identify regulations for fall protection • Define the responsibilities of the person climbing and those of the employer • Identify the risks involved when working at heights • Demonstrate how to inspect of Personal Fall Protection Equipment (PFPE) • Properly don and use a full body harness • Demonstrate the mechanics and performance of each piece of PFPE • Define common hazards for PFPE • Demonstrate how to properly tie and use knots • Demonstrate safe and proper climbing techniques on wind and cell towers • Demonstrate safe and proper rescue techniques on various tower structures
Alternating Current Theory	• Explain the difference between AC and DC • Identify electronic component influence on AC circuits • Define the use of transformers • Describe generator and frequency converter/inverter basics • Explain three phase AC basics • Define electric motor basics • Define reactive poser, impedance and power factor basics
Direct Current Theory	• Define Direct Current • Identify the basic components of a circuit • Identify the source and load • Define HVDC
Voltage Test Procedures (50 Volts or Higher)	• Define volts, amps, ohms • Explain the causes of an Arc Flash event • List the current thresholds that can harm the human body • List the types of Arc Flash PPE required to work on circuits 50 volts or higher • List the types of burns associated with electrocution and arc flash • List the various safety electrical boundaries • Explain the use of insulated electrical tools and how to identify them
	• Demonstrate the inspection process required for different electrical hand tools
Electrical Measurement Safety	• Describe the IEC 61010 category ratings and how they affect the end user • Demonstrate the ability to safely use and care for the metering equipment • Demonstrate the inspection process required for metering equipment • Describe the safety specifications for DMMs and testers • Demonstrate the ability to avoid electrical measurement hazards
Multimeters	• Types of multimeters (analog and digital) • Basic multimeter safety • Basic multimeter functionality • Explain multimeter symbols and their meaning • Demonstrate the inspection process required for multimeters • Describe multimeter care and maintenance
Amp Clamps	• Demonstrate safe and accurate multimeter usage • Define what an Amp Clamp is • Define the symbols on an Amp Clamp • Demonstrate the safe use of an Amp Clamp

Megohmmeters	• Explain basic Megger / Hipot safety • Demonstrate Megger usage
Infrared Testers	• Explain the safe use of an Infrared (IR) tester • Describe the features of an IR tester • Explain the distance to spot ratio • Explain the field of view • Describe Emissivity as it relates to IR scans
Phase Rotation Meter	• Describe what a Phase Rotation Meter is and what it does • Explain the symbols on a Phase Rotation Meters • Demonstrate the safe use of the Phase Rotation Meter
Proximity Sensor	• Describe Proximity Sensor functionality • Demonstrate the safe and accurate Proximity Sensor usage • Demonstrate the three-step procedure using a Proximity Sensor

Electrical Systems, Components, and Schematics	• List the two common electrical drawings used in the field
	• Identify various electrical drawing symbols and labeling
	• Identify potential energy sources on an electrical drawing
	• Identify the elements of:
	  ○ Safety-chain/loop,
	  ○ Latching,
	  ○ Lock-out
	  ○ PLC to Motor-Control
	  ○ Reversing sub-circuits
	• How to interpret block diagrams

Drivetrain Gearboxes	• List the drive train components • Describe the function of each of the drive train components • Explain the gearbox functions
Yaw Systems	• Describe the Yaw control purpose and its operation • Describe wind tracking data interpretation and its devices • Explain component descriptions • Explain the cable untwist function • Explain Yaw system control • Describe possible and likely Yaw system faults
Maintenance Practices	• Explain the importance in following maintenance procedures • Explain possible hazards associated when performing maintenance procedures and mitigation techniques • Identify the consequences of not following proper maintenance procedures
Volt Electrical	• Follow established lockout/tagout procedures • Perform pre-energization checks and follow all electrical safety precautions • Understand schematics to build and troubleshoot motor control circuits • Troubleshoot motor control circuits, components and devices
Basic Hydraulics	• Describe hydraulic systems and what they are used for • Demonstrate interpreting a hydraulic schematic • Explain a basic hydraulic system • Troubleshoot a hydraulic system

Cell Site Basics	• Identify different types of cell towers • Identify ground components and structures • Identify tower components and apparatus
Radio Frequency Awareness	• Define Radio Frequency (RF). • Identify the hazards when working around RF. • Identify how to avoid RF hazards. • Recognize RF signage and their implication/s.
Capstan Hoist Certificate	• Safely and accurately perform a lift using a capstan hoist • Define a capstan hoist and its features • Define anchorages, blocks, ropes, and how to use and inspect them
Lines and Antennas	• Hang and remove an antenna from a tower • Demonstrate rigging techniques • Determine and demonstrate color coding • Perform weatherproofing • Perform grounding for coax line • Define and explain line and antenna procedures
CADWELDING	• Safely and accurately perform a CADWELD on a ground grid system • Define the CADWELD process • Explain safety measures when using CADWELD
Electrostatic Discharge (ESD)	• Define Electrostatic Discharge (ESD) • Identify how ESD damages electronic parts • Define correct handling procedures for ESD sensitive electronic parts
SCADA and Data Analysis	• Define what SCADA is and what it does • Describe information that SCADA produces • Explain the benefits of using SCADA
Fiber Optics	• Define fiber optics • Describe how information passes through a fiber optic system • Differentiate analog and digital operation • Demonstrate light loss measurement • Define the basic components of a fiber optic system • Define how a fiber optic system works on a wind turbine • Define how a fiber optic system works on a cell tower

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