Test Instruments and Electrical Safe Work Practices

- Jim Dollard
- Flintlock Technical Services
- NECA Penn-Del-Jersey Chapter
- IBEW Local 98

This session is eligible for 1.25 Continuing Education Hours.

For these hours to appear on your certificate, you must:

- Have your badge scanned at the door
- Attend 90% of this presentation
- Fill out the online evaluation for this session







NECA SAVETY PROPESSIONALS CONFERENCE

Objectives

- Overview
- Employer/Employee Responsibilities
- First Priority
- Infeasibility/Justified Energized Work
- Related requirements such as training, qualified persons
- Test Instrument Training
- Requirements For Test Instruments

Objectives

- Policy on the Use of Test Instruments
- Toolbox Talks
- Questions





Overview

- Electrical workers engaged in the process of troubleshooting electrical equipment or testing for the absence of voltage <u>are</u> <u>working energized</u>. 1926.416(a)(1) ground or guard
- Inside the LAB?
- Interacting with energized equipment in a manner that increases the likelihood of an arc flash?
- Product standards for test instruments and associated NFPA 70E requirements, have changed significantly to provide safer working conditions for the electrical worker.

NECA SAFETY PROFESSIONALS CONFERENCE



Incidents while using test instruments?

- An example is older style digital multimeters and other test instruments that used metal banana plugs
- These banana plugs were easily pulled out of the test instrument.
- This resulted in many incidents where voltage tests were being performed and the metal banana clip was inadvertently pulled from the test instrument during the task
- Product standards now require test probe plugs to be fully insulated and difficult to remove inadvertently





Justified Energized Work - Thresholds

- Energized work is only permitted when the <u>employer</u> can demonstrate the justification thresholds in NFPA 70E have been met.
- Who is the employer on the jobsite?
- Use of test instruments, in most cases, requires exposure to energized equipment
- Will the employee interact or need to cross the limited approach boundary?

NECA SAFETY PROFESSIONALS CONFERENCE



Justified Energized Work

- 110.3 Electrically Safe Work Condition. Energized electrical conductors and circuit parts operating at <u>voltages equal to or</u> greater than 50 volts shall be put into an electrically safe work condition before an employee performs work if any of the following conditions exist:
- (1) The employee is within the limited approach boundary.
- (2) The employee interacts with equipment where conductors or circuit parts are not exposed but an increased likelihood of injury from an exposure to an arc flash hazard exists.





Likelihood

- The state or fact of something's being likely; probability.
- Take a flight to a vacation destination?
- Plane crash: possible but not probable, its not likely
- Could a meteorite make it through the earths atmosphere and hit right here, right now?
- It is possible, not probable, its not likely

Likelihood

HOPEWELL TOWNSHIP, N.J. — A metallic object that punched a hole in the roof of a central New Jersey home this week, smashing into a hardwood floor and bouncing around a bedroom, was a meteorite, experts announced Thursday. 1 day ago



NBC News
 https://www.nbcnews.com > news > us-news > meteorite-...

Meteorite crashes through roof of New Jersey home and ...





Justified Energized Work INFEASABILITY

- NFPA 70 permits energized work to be performed if the task is infeasible in a deenergized state.
- Infeasible **does not** mean inconvenient, expensive or impractical.
- **110.4(B)** IN.... **diagnostics and testing** (for example, start-up or troubleshooting) of electric circuits that can only be performed with the circuit energized

Qualified Persons Required????

- Qualified Person. One who has <u>demonstrated skills and</u> <u>knowledge</u> related to the <u>construction and operation of</u> <u>electrical equipment</u> and *installations* and has <u>received</u> <u>safety training</u> to <u>identify the hazards</u> and <u>reduce the</u> <u>associated risk</u>.
- Consider a 5 kV chiller starter (4,160-volts)
- Placing a 600-volt test instrument across 4160-volts results in the rapid disassembly of the test instrument
- Training requirements in 110.6.....







EEWP Required???

- 130.2(C) Exemptions to Work Permit. Electrical work shall be permitted without an energized electrical work permit <u>if a qualified person is provided with and uses</u> <u>appropriate safe work practices and PPE in accordance</u> with Chapter 1 under any of the following conditions:
- Testing, troubleshooting, or voltage measuring
- <u>Thermography, ultrasound, or visual inspections if</u> <u>the restricted approach boundary is not crossed</u>

Likelihood of Occurrence of an Arc Flash Incident

- <u>Thermography</u>, ultrasound, or visual inspections <u>if the</u> restricted approach boundary is not crossed
- Interacting in a manner that increases likelihood of an arc flash?
- See Table 130.5(C) Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems

Likelihood of Occurrence of an Arc Flash Incident

- Understanding requirements in Table 130.5(C) requires an understanding of a risk assessment
- A risk assessment is a process
- Four steps. Not just one!





Likelihood of Occurrence of an Arc Flash Incident

Risk Assessment. An overall process that identifies hazards,.....

Likelihood of Occurrence of an Arc Flash Incident

• Risk Assessment. An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health,.....



• Risk Assessment. An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health,.....

Likelihood of Occurrence of an Arc Flash Incident

NSPC

• Risk Assessment. An overall process that identifies hazards, estimates the likelihood of occurrence of injury or damage to health, estimates the potential severity of injury or damage to health, and determines if protective measures are required.



NS PC



Shock Risk Assessment

- NFPA 70E requires a Shock Risk Assessment be performed to identify shock hazards.
- Establish Shock Protection Boundaries based on nominal phase to phase Voltage
- Apply the Hierarchy of Controls to mitigate risk, including PPE.

Arc Flash Risk Assessment

- NFPA 70E requires that an Arc Flash Risk Assessment be performed to identify arc flash hazards.
- Determine the likelihood of an occurrence and the severity of potential injury.
- Apply the Hierarchy of Controls to mitigate risk including Arc Flash PPE.



General Training in 110.6

- NFPA 70E mandates that all employees that may be exposed to electrical hazards (not reduced to a safe level by the applicable electrical installation requirements) shall be trained and <u>qualified</u> for the task.
- Use of test instruments....
- Requirements in 110.6(A)(1)

General Training in 110.6

- Trained in:special precautionary techniques, <u>applicable electrical policies and procedures</u>, PPE, insulating and shielding materials, and insulated tools and test equipment
 - Policies and Procedures

NSPC

- Does your company have a policy, procedures or best practices with respect to test instruments?
- Who, What, When, Where, Why





General Training in 110.6

- A person can be considered qualified with respect to certain equipment and tasks but still be unqualified for others
- Does that apply to test instruments?
- Systems, voltages, types/models of test instruments

General Training in 110.6

- Inside LAB.....
- Skills and techniques necessary to distinguish exposed energized electrical conductors and circuit parts from other parts of electrical equipment
- <u>Skills and techniques</u> necessary to *determine the nominal voltage* of exposed energized electrical conductors and circuit parts





Ge

- Approach distances specified in Table 130.4(E)(a) for ac and Table 130.4(E)(b) for dc and the corresponding voltages
- Nominal system voltage range, phase-to-phase
- AC 50 through 150 volts: 3-feet, 6-inches

General Training in 110.6

• AC 151 through 750 volts: 3-feet, 6-inches

General Training in 110.6

- Decision-making process necessary to be able to do the following:
 - Perform the job safety planning
 - Identify electrical hazards
 - Assess the associated risk
 - Select the appropriate risk control methods from the hierarchy of controls identified in 110.5(H)(3), including PPE





General Training in 110.6

• Employees shall be trained to <u>select an appropriate test</u> <u>instrument</u>

General Training in 110.6

• Employees shall be trained to <u>select an appropriate test</u> <u>instrument</u> and <u>shall demonstrate how to use a device</u> to <u>verify</u> (test in 120.5) the absence of voltage,







• Employees shall be trained to <u>select an appropriate test</u> <u>instrument</u> and <u>shall demonstrate how to use a device</u> <u>to verify the absence of voltage</u>, including <u>interpreting</u> <u>indications provided by the device.....</u>

General Training in 110.6

• Employees shall be trained to <u>select an appropriate test</u> <u>instrument</u> and <u>shall demonstrate how to use a device</u> <u>to verify the absence of voltage</u>, including <u>interpreting</u> <u>indications provided by the device</u>. The training shall include information that enables the employee to <u>understand all limitations of each test instrument</u> that might be used.



Document, Document, Document

- **110.6(C)(4) Documentation.** The employer shall document that the training required by110.6(C) has occurred.
- What test instrument training is required?
- Section 110.8(A) mandates that only <u>qualified persons</u> shall perform tasks such as testing, troubleshooting, and voltage measuring on electrical equipment <u>where</u> <u>an electrical hazard exists.</u>

NEA SAFETY PROFESSIONALS CONFERENCE

Test Instrument Policy

- Who purchases, supplies, and maintains test instruments in your Local? Different in most areas!
- Some CBA's require JW bring a "voltage tester"
- Do you know what test instruments are on your job sites? Do you have a list?
- Have any been recalled?
- Have you trained on each and every type?

Test Instrument Policy

- One idea that works is to purchase digital voltage testers with a policy that mandates only those test instruments be used to troubleshoot/voltage and test for the absence of voltage
- That training is elementary, pdf's supplied by the manufacturer, only used for voltage or continuity
- Multimeters on the other hand, can get complicated

General Training – Qualified Person

- NFPA 70E defines a qualified person, but the employer determines who is qualified for each task
- In order to be considered a qualified person:
 - Must be trained and knowledgeable in the construction and operation of the equipment involved
 - Knowledgeable in the specific work methods to be used
 - Trained and able to identify and avoid electrical hazards
 - Trained and able to perform required job safety planning
 - Trained and able to perform necessary <u>Shock and Arc Flash risk</u>
 <u>assessment</u>
 - Apply Hierarchy of Risk Controls including any necessary PPE



Test Instruments, 110.8

- 110.8 Test Instruments and Equipment.
- **110.8(A) Testing.** Only <u>qualified persons</u> shall perform tasks such as testing, troubleshooting, and voltage measuring on electrical equipment *where an electrical hazard exists*.

Does an Electrical Hazard Exist?



Electrical Hazard Exists?



Test Instruments, 110.8

- **110.8(B) Rating.** Test instruments, equipment, and their accessories shall be as follows:
- (1) Rated for circuits and equipment where they are utilized
- (2) Approved for the purpose
- (3) Used in accordance with any instructions provided by the manufacturer



Requirements for Test Instruments RATING & DESIGN

- Test instruments, associated equipment, and all accessories must be rated for the circuits and equipment on which they will be used.
- Ratings include but are not limited to:
 - Nominal Voltage
 - Current and Overvoltage Category Ratings
- The NECA guide is focused primarily on utilizations equipment and test instruments with ratings of 600V and 1000V

Requirements for Test Instruments RATING & DESIGN

- Test instruments have overvoltage ratings that are identified by categories based upon the potential overvoltage exposure on a system.
- Qualified persons must be trained to understand the application of overvoltage ratings/categories on test instruments

Requirements for Test Instruments CATEGORIES

• These categories are: CAT I, CAT II, CAT III, CAT IV.



NSPC

- Using test instruments with without proper category rating for the task exposure can result in a test instrument exploding due to transients
- **IMPORTANT NOTE** The Categories on Test Instruments have <u>NO</u> correlation to the Category rating of Arc Flash PPE.



CAT III 600V



Test Instruments, 110.8

 110.8(D) Visual Inspection and Repair. Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be <u>visually inspected for external</u> defects and damage before each use. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item <u>shall be removed from service</u>. No employee shall use it until a person(s) qualified to perform the repairs and tests that are necessary to render the equipment safe has done so.



Requirements for Test Instruments INSPECTION

- Employees must be trained to perform visual inspections on test instrument for external defects and damage.
- This includes associated equipment like:
 - Test Leads
 - Cables
 - Power Cords
 - Probes
 - Connectors



Requirements for Test Instruments REPAIR

- Where defects or damage is identified, the damaged or defective item(s) must be removed from service immediately.
- Repairs must be performed by a qualified person(s)
 - Manufacturer
 - Authorized repair facilities

Requirements for Test Instruments STORAGE & CARE

- Proper storage of test instrument and associated components to prevent damage.
- Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors must be cared for properly and not exposed to damage.

Test Instruments, 110.8

• **110.8(E) Operation Verification.** When test instruments are used for testing the absence of voltage on conductors or circuit parts operating at voltages equal to or greater than 50 volts, the operation of the test instrument shall be verified on any known voltage source before and after an absence of voltage test is performed.



Training – Test Instruments

• NFPA 70E requires that all qualified persons be trained to select an appropriate test instrument for the task to be performed.

NSPC

• Additional training on the use of electrical test instruments is required when new technologies or new/different types of test instruments will be used.







Training – Test Instruments

- Permitted types of training for test instruments include classroom, on-the-job, or a combination of both.
- NFPA 70E clarifies that classroom training can include interactive electronic or interactive web-based training components.

Requirements for Test Instruments REPAIR

- Where defects or damage is identified, the damaged or defective item(s) must be removed from service immediately.
- Repairs must be performed by a qualified person(s)
 - Manufacturer
 - Authorized repair facilities





Requirements for Test Instruments ABSENCE OF VOLTAGE

- NFPA 70E provides prescriptive direction on how to test for the absence of voltage in the process provided for establishing and verifying an ESWC
- Absence of voltage prescriptive steps in 120.5(7):
 -test each phase conductor or circuit part to test for the absence of voltage.
 - Test each phase conductor or circuit part both phase-tophase and phase-to-ground



Non-contact test devices are **<u>not permitted</u>** to be used for testing for the absence of voltage.





Indication ONLY!

- Non-contact voltage detectors play a significant role in safety
- That role is Indication of the presence of voltage ONLY
- Prohibited for absence of voltage tests
- Significant limitations
- Training is required!
- 130.7(C)(1) IN..... Risk Reduction Methods



Risk Reduction Methods 130.7(C)(1) IN

Informational Note: Where the estimated incident energy exposure is greater than the arc rating of commercially available arc-rated PPE, then for the purpose of testing for the absence of voltage, the following examples of risk reduction methods could be used to reduce the likelihood of occurrence of an arcing event or the severity of exposure:

(1) Use noncontact proximity test instrument(s) or measurement of voltage on the secondary side of a low-voltage transformer (VT) mounted in the equipment before using a contact test instrument to test for the absence of voltage below 1000 volts.

(2) If equipment design allows, observe visible gaps between the equipment conductors and circuit parts and the electrical source(s) of supply.

(3) Increase the working distance.

(4) Consider system design options to reduce the incident energy level.

Types of Test Instruments

- There are many types of test instruments used by electrical workers.
- The most common types of test instruments used for voltage testing include but are not limited to:
 - Solenoid-based voltage testers
 - Electronic/digital voltage testers (similar in size and shape to a solenoid-based voltage tester)
 - Digital Multimeters used in some cases.



Solenoid Type Voltage Testers

- •Very popular and most electrical workers own and use them regularly.
- •Commonly used up to 480 volts
- •These devices are momentary contact type testers and cannot be held in place on an energized circuit.
- •These devices have limitations on the lower voltage range.



Electronic/Digital Voltage Testers

- Similar in size, shape and design to a solenoid-based voltage tester.
- They are typically capable of measuring voltage from 12 to 600 volts.
- Potential for false positive (ghost voltage) created through induction from an energized conductor.







Digital Multimeters

- Digital multimeters are commonly used for testing for the absence of voltage and troubleshooting but do much more than measure voltage.
- Can be used to measure:
 - VOLTAGE
 - CURRENT
 - RESISTANCE
 - And more.....

Phase Rotation

- Phase rotation instruments are commonly applied where modifications to electrical distribution systems are performed.
- Electrical workers must determine the phase rotation to ensure proper operation of three phase motor loads
- Non-contact phase rotation instruments are readily available and significantly reduce the likelihood of an incident.



Absence of Voltage Testers

NFPA 70E 120.5(7) Exception No. 1 permits the use of a permanently mounted Absence of Voltage test device (AVTs) meeting the following criteria:

- 1. List and labeled as Absence of Voltage tester.
- 2. Permanently mounted and installed in accordance with manufacturer's installation instructions.
- 3. Performs verification test on known live source before and after Absence of Voltage test.
- 4. Tests each phase independently Phase to Phase and Phase to Ground.







Voltage Indicators

- Permanently mounted devices that use an LED style indicator to illuminate when voltage is present
- Not permitted for Absence of Voltage testing
- Indication only



Image courtesy of GRACE Technologies®

Test Portals

- Test portals are permanently mounted devices that can be used with a portable test instrument such as an electronic voltage tester or a digital multimeter.
- Test portals are <u>not permitted to be used to</u> <u>test for the absence of voltage.</u>
- These devices do not perform all the functions required by NFPA 70E to test for the absence of voltage.





Requirements for Test Instruments COMPANY POLICY

- NFPA 70E sets the guidelines for employers
- Policy must be developed to support employee safety related to the use of test instruments
- Policy effectively communicates employee expectations
- Employer Commitment is key
- Best Practices support employer's policy

Requirements for Test Instruments STRATEGY FOR POLICY DEVELOPMENT

- Identify Policy Needs and Unique Company Specific Elements
- Include key stakeholders i.e., management, employees, and customers.
- Brainstorming or small work group discussions
- Purpose Statement (Why does the Policy Exist)
- Approved and endorsed by leadership (i.e., BOD, President, CEO)



Sample Policy-Test Instruments PURPOSE

This policy is written to outline requirements for the use of test instruments for all [Company Name] employees. Only qualified persons, trained in the use of the specific test instrument are permitted to use a test instrument where electrical hazards exist. The person in charge of the project, such as a project manager (PM), field superintendent, general foreman is typically responsible for enforcing this policy on all jobsites. This assigned responsibility can vary between companies.

Sample Policy - Test Instruments DESCRIPTION

Who does the policy apply to?

All employees trained in electrical safe work practices

What does this policy require of the employees?

- Must be trained in the use of a [Model] solenoid tester and a [Model] electronic type voltage tester for testing, troubleshooting and testing for Absence of Voltage
 Must be trained to identify the rating of Test Instruments (Voltage and Category)
- Risk Assessments
- ESWC
- · Additional training on specific or new test instruments
- · Trained in the use of permanently mounted AVTs
- Identify required PPE



Sample Policy - Test Instruments DESCRIPTION

What does the policy prohibit?

- Shall not use noncontact testers for Absence of Voltage testing
- Shall not use damaged test instruments/components
- · Shall not use test portals or voltage indicators for Absence of Voltage
- Shall not use contact type phase rotation instruments

What documentation is required?

- Training
- Test Instrument Calibration Records
- Risk Assessments
- Manufacturer's Instructions



Sample Policy – Test Instruments **BEST PRACTICES**

- Best Practices and Procedures are the detailed steps by which policy compliance is achieved
- · Best Practices or procedures go hand-in-hand with policies.
- · Best Practices are techniques or methods that have proven to be more effective at delivering a particular outcome than any other.



Sample Policy – Test Instruments DEVELOPING BEST PRACTICES

- 1. Identify problem areas
- 2. Identify other companies or industries that have similar processes
- 3. Identify the leaders in these areas
- 4. Survey companies for measures and practices and/or review accepted industry standards
- 5. Determine which practices have proven results
- 6. Implement the practices



Sample Policy – Test Instruments DEVELOPING BEST PRACTICES

- A Best Practice Should Include:
 - Title

VSPC

- Statement
- Description
- Benefits
- References

