Electrical Safety Innovation

How today’s technology is enabling the next-generation of electrical LOTO

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Agenda

1. Review Prevention through Design, Hierarchy of Controls, Electrical Hazards
2. Electrical LOTO Example
3. Voltage Testing Technologies
4. Best practices for evaluating and applying electrical safety technology
Prevention through Design, Hierarchy of Controls & Electrical Hazards
Prevention through Design (PtD)

The practice of anticipating and designing out hazards as early as possible in the lifecycle of a product

- Applies throughout organization
- Think new & existing equipment
- Consider entire lifecycle
Hierarchy of Risk Controls

Most Effective

Elimination
- Physically remove the hazard

Substitution
- Replace the hazard

Engineering Controls
- Isolate people from the hazard

Administrative Controls
- Change the way people work

PPE
- Protect the worker with Personal Protective Equipment

PtD Focus

Least Effective
Lockout Tagout (LOTO)

Control of Hazardous Energy
OSHA 29 CFR 1910.147

- Chemical
- Electrical
- Hydraulic
- Mechanical
- Pneumatic
- Thermal
Electrical Hazards

- Shock
- Arc flash
- Fire

Electrical hazards impact everyone – not just electrical workers!
Time for Innovation

The number of electrical injuries is **no longer decreasing**

Many believe electrical injuries are **underreported**

Frequency of Electrical Incidents

Question: Have you experienced any of the following within the past five years?

- We don't track this information: 8%
- Prefer not to answer: 7%
- Incidents related to voltage testing: 18%
- Electrical incidents: 40%
- Electrical incident near misses: 68%

Source: EHS Today – 2019 Survey
Example:
Electrical Lockout/Tagout
LOTO...and then **Verify!**
NFPA 70E   120.5 Process for Establishing and Verifying an
Electrically Safe Work Condition

(7) Use an adequately rated portable test instrument to test each phase conductor or circuit part to verify it is de-energized. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source.
Portable Testers Have Limitations

Error Setting Function Selection Switch
Electrician severely burned when a multimeter switch was incorrectly placed in resistance mode prior to making contact with terminals in a 480V MCC.[1]

Inadequately Rated Tester
Arc created when a voltmeter was connected across two phases of a bus bar. Arc caused tester to overload and explode resulting in one fatality and another worker with serious burn injuries.[2]

Error Reading Digital Display
“OL” or over-range was misinterpreted to mean “zero” or no voltage present, resulting in a near-miss.[1]

Use of Improper Portable Tester
Although a non-contact voltage probe did not indicate voltage, a lighting circuit was in fact energized, resulting in electrical shock.[3]

Using a Voltmeter for verification has limitations…
- Hardware failures
- Human error
- Process failures
- Misinterpretation
- Exposure to hazards

LOTO and Verification

Traditional process relies on:

- Portable testers
- Procedures
- Training
- Personal protective equipment
Administrative Controls

Effective when **performed as prescribed**

Normalization of deviance

Complexity leads to **shortcuts**

Experience does **not mean fewer errors**

- **Elimination**
- **Substitution**
- **Engineering Controls**
- **Administrative Controls**
- **PPE**
Human Factors

- Multi-tasking
- Assumptions
- Familiarity with Task
- Overconfidence
- Skills
- Work Load
- Distractions
- Work Environment
- Unexpected Configurations
- Familiarity with Equipment
- Communication
- Experience Level
- Repetitive actions
- Skills
- Time Pressure
- Task Demands
- Personality Conflicts
- Familiarity with Equipment
- Unclear Responsibilities
- Interruptions
- Illness
- Fatigue

- Stress
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In a study of electrical burn patients, researchers found that no patient in the study followed all appropriate safety measures.

Can design options make voltage testing more efficient?

Could design features help ensure each step of the process is completed?

Can exposures be reduced?
Applying Prevention through Design

Use of an **installed** tester
- Reduces **likelihood** of exposure and **severity** of exposure
- Reduces **errors** from inadequately rated testers

**Automating** the test process
- Improves **consistency** of the verification process
- Reduces **human errors**
- Improves **efficiency**
Verifying a De-Energized Condition

NFPA 70E-2021 120.5 Process for Establishing and Verifying an Electrically Safe Work Condition

CSA Z462-2021 4.2.5 g) Exception 2) & Note 1

(7) Use an adequately rated portable test instrument to test each phase conductor or circuit part to test for the absence of voltage. Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on any known voltage source.

Exception No. 1 to (7): An adequately rated permanently mounted absence of voltage tester shall be permitted to be used to test for the absence of voltage of the conductors or circuit parts at the work location, provided it meets the all following requirements:

1) It is permanently mounted and installed in accordance with the manufacturer’s instructions and tests the conductors and circuit parts at the point of work
2) It is listed and labeled for the purpose of verifying the absence of voltage
3) It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground
4) The test device is verified as operating satisfactorily on any known voltage source before and after testing for the absence of voltage

Informational Note No. 2. For additional information on rating and design requirements for permanently mounted absence of voltage testers, refer to UL 1436, Outlet Circuit Testers and Other Similar Indicating Devices.
Exception No. 1: An adequately rated permanently mounted test device shall be permitted to be used to verify the absence of voltage of the conductors or circuit parts at the work location, provided it meets the all following requirements: (1) It is permanently mounted and installed in accordance with the manufacturer’s instructions and tests the conductors and circuit parts at the point of work; (2) It is listed and labeled for the purpose of verifying the absence of voltage; (3) It tests each phase conductor or circuit part both phase-to-phase and phase-to-ground; (4) The test device is verified as operating satisfactorily on any known voltage source before and after verifying the absence of voltage.

Typically measurement devices indicate when voltage is present, but lack of indicating a voltage does not guarantee the equipment has been de-energized. For this reason, these mounted devices are designed to run internal diagnostics, verify operation on a known voltage source, confirm contact with the circuit, and verify the lack of voltage. These measurement devices do not use equipment voltage to verify the operation of the device. A secondary test source is available to perform this function. The device will then actively indicate the lack of voltage. See Exhibit 120.14 for an installed absence of voltage tester indicating that equipment is de-energized. Absence of voltage testing equipment for fixed installations is listed to UL 1436, Standard for Outlet Circuit Testers and Similar Indicating Devices.
Comparison of Test Methods

Portable Testers

Select Tester → Open Panel → Test Tester → Check for Voltage → Retest Tester → Perform Work

Manual Process
Possible Exposure to Electrical Hazards
On average takes **10-20 minutes** to complete

Absence of Voltage Testers

Activate the VeriSafe™ Absence of Voltage Tester

Test the Tester → Verify Installation → Check for Voltage → Re-Verify Installation → Re-test the Tester → Indicate Result

Automatically Performed in Sequence
No Exposure to Electrical Hazards
Takes **less than 10 seconds** to complete
Permanently-Mounted Absence of Voltage Tester

Test before doors are open

Keep hazardous voltage away from door

Hardwired connections to each phase and ground
Traditional Method with **Portable Tester**

Using a **Permanently-Mounted Absence of Voltage Tester (AVT)**
VeriSafe™ Absence of Voltage Tester

Combines **Voltage Presence** Indication with **Absence of Voltage Testing**

- Red LEDs indicate hazardous voltage present
- Lack of red LEDs **does not guarantee** voltage absence
- Push to initiate test and see progress
- Green indicates **absence of voltage** is confirmed

![Images of different states of the VeriSafe™ Absence of Voltage Tester showing upstream power on and off.](image-url)
UL 1436

AVT Listing & Labeling Requirements
Key AVT Requirements

UL 1436 Standard for Outlet Circuit Testers and Similar Indicating Devices, 6th Edition (September 6, 2016)

User initiated test

Installation test & “test the tester”

Test for AC and DC voltage

Active indication

Internal overcurrent protection

Keep Hazardous voltage off the door

Electrical requirements in UL 61010

Functional safety requirements
Electrical Construction

- IEC 61010 Provides general safety requirements for electrical and test measurement equipment
  - Protection from electrical shock
  - Electrical spacing and insulation requirements
  - Impulse and transients
  - Mechanical impact
  - Environmental hazards

- Electrical construction requirements are based on combination of Overvoltage Category and Working Voltage
  - CAT IV 1000V – 12 kV impulse
  - CAT IV 600V – 8 kV impulse
  - CAT IV 300V – 6 kV impulse
  - CAT III 1000V – 8 kV impulse
  - CAT III 600V – 6 kV impulse
  - CAT III 300V – 4 kV impulse
Functional Safety and VeriSafe AVTs

- Any part of the AVT **safety function** must meet **SIL 3 requirements**
- The VeriSafe AVT exceeds SIL 3
  - Hazardous failure rate (λDU) of 10
  - Probability Failure per Hour (PFH) of $10^{-8}$

$10^{-8}$ equates to **1 failure** per:

- 100 million operating hours
- 11,000+ years
- 36 billion tests
Use Cases
Access Control

Reduce workplace hazards through design

Provides an added layer of protection
Next-Generation of Electrical LOTO

Traditional Process

- Elimination
- Substitution
- Engineering Controls
- Administrative Controls
- PPE

Automated System

- Reduced exposure to hazards
- Fewer opportunities for human error
- Improved efficiency
Absence of Voltage Testers & Lockout/Tagout

Test for de-energization of the Engel injection mold machine using the VeriSafe AVT. Green light indicates circuit is de-energized. Hydraulic pressure at Gages should go to 0. Attempt to start or operate the equipment.
Equipment with AVTs

Control Panels, Motor Control Centers, Safety Switches, Switchgear, Switchboards, Transformers, Packaged Drives, Bus Duct, etc.

AVTs are solutions for
✓ New equipment
✓ Retrofits
✓ OEM installations
Comparing Voltage Testing Technologies
“But I Trust My Portable Tester...”

<table>
<thead>
<tr>
<th></th>
<th>Typical Portable Tester</th>
<th>VeriSafe AVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can see what I’m testing</td>
<td>Exposure to hazards, conductors may not be exposed</td>
<td>Connectivity is part of every test</td>
</tr>
<tr>
<td>Functionality Test</td>
<td>Live-Dead-Live</td>
<td>Automatic Live-Dead-Live with Built-in Known Voltage Source</td>
</tr>
<tr>
<td>Voltage Rating</td>
<td>Varies</td>
<td>Up to 600V</td>
</tr>
<tr>
<td>Overvoltage CAT</td>
<td>CAT III / IV</td>
<td>CAT III (600) / CAT IV (300)</td>
</tr>
<tr>
<td>UL Listing</td>
<td>UL 61010 or IEC 61243-3</td>
<td>UL 61010, UL 1436, UL 508</td>
</tr>
<tr>
<td>Functional Safety</td>
<td></td>
<td>SIL 3</td>
</tr>
<tr>
<td>Third-party certification</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Portable Testers Have Risk

- Inadequate ratings
- Exposure to Hazards
- Human Error
- Misinterpretation of Settings or Readings
- Damaged or improperly installed probes
- Access to a known voltage source
- Lack of contact with conductors or ground
Voltage Testing Traps

AVT Sensor Leads

Insulated Conductors

Barriers

Finding a Reliable Ground

Fuses & Accessories

Obstructed Access/Poor Visibility
## Terminology Matters

### Portable Test Instruments

<table>
<thead>
<tr>
<th>Digital Multimeter</th>
<th>Voltage Detector</th>
<th>Voltage Presence Indicator / Voltage Detector</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL/IEC 61010</td>
<td>IEC 61243-3</td>
<td>UL 1436 / UL/IEC 61010</td>
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### Permanently Mounted Products

<table>
<thead>
<tr>
<th>Absence of Voltage Tester (AVT)</th>
<th>Voltage Indicator</th>
<th>Voltage Portals</th>
<th>Analog or Digital Panel Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1436 / IEC/UL 61010</td>
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</table>
Importance of the Installation Test

Voltage Indicator

Test Portal

Absence of Voltage Tester

How do you verify installation?
Best Practices

evaluating and applying electrical safety technology
Future Vision

A connected infrastructure...designed for safety.

- Qualified electrical worker with ID credentials
- Permanently-mounted AVT
- Access control at the enclosure
- Voltage test results logged for auditing
- Training records
Summary

• To advance electrical safety, embrace the continuous improvement mindset
  • Leverage the near miss

• Use Prevention through Design when mitigating hazards
  • Control measures that are designed in are more effective than administrative controls and PPE alone

• Seek out new technology and innovation
  • New solutions to old problems like LOTO and verification are now viable
How can you apply PREVENTION THROUGH DESIGN at your organization?