

Facility: DOE Complex

Best Practice Title: Guidance for Installation and use of Permanently Mounted Test Devices

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Brief Description of Best Practice: There have been significant advancements in the technologies available for protecting workers from exposure to electrical hazards. Products such as the Absence of Voltage Tester (AVT) and the Voltage Test Station (VTS) can reduce and, in many cases, eliminate the risk of exposure to shock and arc flash hazards while performing voltage measurements. This best practice was developed by the Energy Facility Contractor Group - Electrical Safety Community of Practice (EFCOG-ESCoP) to provide recommendations and guidance regarding installation and use of permanently mounted test devices for the testing of voltage.

Why the best practice was used: NFPA 70E "The Standard for Electrical Safety in the Workplace" 2018 edition allowed the use of permanently mounted test devices to verify absence of voltage at the work location. Guidance is needed regarding installation and use of permanently mounted test devices.

What are the benefits of the best practice: Provide recommendations and guidance regarding installation and use of permanently mounted test devices for the testing of voltage.

What problems/issues were associated with the best practice: N/A (New best practice)

How the success of the Best Practice was measured: N/A (New best practice)

Description of process experience using the Best Practice: N/A (New best practice)



Electrical Safety Community of Practice

Guidance for Installation and use of Permanently Mounted Test Devices

Best Practice # 268

Introduction

Exposure to hazardous electrical energy sources is a concern that can be difficult to mitigate in all scenarios. There have been significant advancements in the technologies available for protecting workers from these hazards. Products such as the Absence of Voltage Tester (AVT) and the Voltage Test Station (VTS) were engineered to reduce and, in many cases, eliminate the risk of exposure to shock and arc flash hazards while performing voltage measurements.

Absence of voltage testing is one of the critical steps to establishing an electrically safe working condition in accordance with 29 CFR 1910 Subpart S and NFPA 70E. Portable test instruments (PTI) i.e., voltmeters, have a proven reputation and are the preferred instrument for many of those who perform the test. Those who perform absence of voltage testing have confidence that voltmeters will ensure a source of electricity is correctly isolated, and the circuit is de-energized prior to performing work. Once an electrically safe working condition is established, the risk of personnel exposure to hazardous electrical energy is eliminated.

The performance of the absence of voltage test using a PTI is not without risk and personal protective equipment (PPE) is required until an electrically safe working condition has been established. The risk to employees performing absence of voltage testing has led to the development of products that can reduce and, in some cases, eliminate exposure to electrical hazards while performing absence of voltage tests.

NFPA 70E “The Standard for Electrical Safety in the Workplace” recognizes that personnel who perform absence of voltage testing are exposed to potential electrical hazards and, in the 2018 edition, allowed the use of permanently mounted test devices to be used to verify the absence of voltage at the work location if the devices met the following four criteria

1. The device 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. The device is listed and labeled (UL-1436) for the purpose of verifying the absence of voltage.
3. The device tests each phase conductor or circuit part both phase to phase and phase to ground.
4. The device is verified as operating satisfactorily on any known voltage source before and after verifying the absence of voltage.

Discussion

This best practice was developed by the EFCOG Electrical Safety Community of Practice (EFCOG-ESCoP) to provide recommendations and guidance regarding installation and use of permanently mounted test devices for the testing of voltage. These recommendations are in addition to the manufacturer's instructions and are not intended to supersede or modify those instructions.

NOTE: *The AVT and VTS pictured in this document are for illustrative purposes only and are not intended to imply a preference of device type or manufacturer.*



Voltage Test Station (VTS)

A VTS extends the location of voltage test points to the exterior of electrical equipment allowing tests to be performed while the equipment doors are closed and covers secured. The design of VTSs can vary, but common features may include any combination of high impedance connections, IP rated test points, covers preventing unauthorized access, and LED indicator lights to name a few. The VTS relies on a separate PTI to perform voltage testing. A VTS can eliminate the need for shock and arc flash personal protective equipment (PPE) by utilizing finger safe (IP-20 rated) test points in combination with high impedance connections that eliminate the shock and arc flash hazards. Voltage testing is performed in a traditional sense using a PTI without exposure to electrical hazards. Absence of voltage testing for the establishment of an electrically safe working condition would need to be performed using an administrative procedure.

By design, a VTS cannot perform a self-check function, so the VTS alone cannot prove operability and as such without additional requirements cannot be used to establish an electrically safe working condition. The use of a VTS can provide the worker with an absence of voltage test compliant with NFPA 70E, Section 120.6(7) under the following condition: the VTS is verified to be operational by confirming the phase to phase and phase to ground voltage to which the VTS is connected is present, prior to deenergizing the circuit and establishing an electrically safe work condition. Once the equipment or circuit is de-energized a second voltage check would still need to be performed at the VTS to ensure an electrically safe working condition has been established.



Absence of Voltage Tester (AVT)

The user must be familiar with the equipment and authorized to perform absence of voltage testing to establish an electrically safe working condition for LO/TO.

Considerations for use:

For an AVT to be listed per UL-1436, the device must provide green illumination indicating an absence of voltage only when the circuit being tested is less than 3 volts. It must also maintain a Safety Integrity Level 3 (SIL3) rating. For many AVTs, this is done by including specific installation instructions, such as multiple leads per phase that must be landed separately. As a result of its requirements, there are several ways for an AVT to fail to provide verification of hazardous energy. Below is a list of known issues that should be considered prior to installation. This list should not be considered exhaustive.

1. The voltage sensed may be greater than 3 volts without being greater than 50 volts in situations where long feeder circuits are run in parallel in cable trays. This mode will present itself as an invalid test rather than as a successful test with an illuminated green light.
2. Equipment may have circuits that are not associated with the main input. This can include metering, UPS circuits, control power, or other such sources. While these sources should be labeled, care should be taken to verify the absence of these sources or to install test means on these sources.
3. Batteries for AVTs may not contain enough charge to provide a valid test. For units that do not contain batteries and instead use methods like super-capacitors to power the test, extended outages may pose a problem after they discharge.
4. Many AVTs take up a lot of space within the enclosure, so cable routing in equipment like panel boards should be evaluated to verify proper clearances for the installation. In some applications it may be feasible to install the device nearby.
5. The manufacturer requirements generally specify the phase and ground leads for permanently mounted test devices shall be made independently, i.e., not on the same lug or termination.
6. The installation should be inspected and approved by the Electrical Authority Having Jurisdiction (AHJ) or their delegate. This individual should have specific knowledge of the device itself.
 - o UL-1436 36.7 requires all permanently mounted test devices to indicate the location being tested by the device (line, load, or bus as appropriate). Ensure this label is installed as a part of the equipment inspection.

Other Considerations applicable to AVT and VTS:

- Permanently mounted test devices are intended to be used on a single source of electrical energy. The use of multiple test devices may be required when system configurations are more complex. Circuits that originate externally from equipment i.e., the line side of a circuit breaker or auxiliary contacts in a motor control center, switchgear heaters, and direct current sources must be taken into consideration to prevent an error likely situation that could expose personnel to hazardous electrical energy.
- Permanently mounted test devices are recommended to be installed in all new and existing electrical equipment where practical to reduce personnel exposure to shock and arc flash hazards when performing absence of voltage verifications. Special consideration for installation of these devices should be given to electrical equipment that poses a greater risk to personnel such as those that require removal of large doors, bolted covers, or other circumstances that increase risk to employees when accessing test points or where high incident energy levels exist.
- Permanently mounted test devices are recommended to be included as part of the specification and procurement of all new switchgear, switchboards, motor control centers, panelboards, and other electrical equipment so that the installation and use is covered under the original NRTL listing for the equipment. Equipment purchased with pre-installed AVTs should be inspected to ensure the installation complies with the AVT manufacturer's instructions.
- The field installation of permanently mounted test devices may challenge the NRTL listing of the equipment but may be acceptable to the Electrical AHJ or their delegate if performed correctly. Examples of situations that may impact acceptability include hazardous locations and unique environmental conditions.
- The VTS does not comply with UL-1436 because the VTS is not testing the circuit for absence of voltage. The VTS provides a test port the worker can use to test for absence of voltage where they will not be exposed to an electrical hazard. As such, a PTI will still be required to perform the absence of voltage test which complies with NFPA 70E, Article 120.6(7).
- Consider placing a site-specific label near all permanently mounted VTSs to indicate the location being tested by the device (line, load, or circuit part as appropriate).
- **Recommendations for Installation:**
 - The decision to connect the permanently mounted test device to the load side or line side of equipment should be known in advance, depending on where the expected LO/TO and absence of voltage testing will be performed. If the equipment serves as the primary LO/TO isolation for downstream equipment where work will be performed, then the load side is adequate. If the device is being installed within a major piece of equipment that needs to be de-energized on both the line and load side, then using it to verify the line side of the main might be appropriate, or the load side of the next upstream disconnecting means. A label indicating where the absence of voltage test is performed (i.e., Line or Load) shall be installed near the device per manufacturer instructions.
 - a. In situations where multiple permanently mounted test devices are installed, HPI principles need to be applied.

- i. If multiple are installed on a removable cover, methods to verify proper reassembly need to be developed to maintain the integrity of the original installation.
 - ii. Modifications to equipment that have permanently mounted test devices should have AVTs reevaluated for installation integrity.
- b. The use of devices that tap into the power wiring is acceptable if they are NRTL listed.
- c. A step in the periodic maintenance procedure for the equipment where the device is installed should be added to reverify the configuration of the equipment has not changed in a way that invalidates the absence of voltage tests. Consider requiring inspection of the device, its components, wiring and connections for damage and loose connections.

Recommendations for Use/Application:

- If the AVT is rated for the environment, they should be strongly considered when possible.
- Maintaining system configuration becomes even more critical than before due to the potential for equipment modifications to inadvertently change the test points and invalidate the test.
 - An example of this is where an AVT is installed on the main of a panel with no other sources. If a solar array is tied into this panel later, the designers and operations staff would need to be aware of the presence of the AVT and either add another or ensure that internal procedures prevent staff from entering without the PPE necessary required to work on or near the solar array source.
- A site inspection process with a specific emphasis on AVTs should be considered to track where AVTs have been installed and how they have been installed.
 - An example of this process is to establish an asset label that provides assurance to the field worker that a knowledgeable inspector has validated the installation.

Conclusion/Recommendations

The EFCOG-ESCoP reviewed NFPA 70E requirements, reviewed manufacturers' literature and consulted with several national labs who have or are considering installing these devices. The EFCOG-ESCoP determined that the use of permanently mounted test devices is a significant step in reducing overall employee exposure to hazardous electrical energy by eliminating employee exposure when performing voltage testing. Using permanently mounted test devices also supports the preferred Hierarchy of Risk Control Methods in NFPA 70E 110.1(H)(3) and embraces ISMS Guiding Principle 6 and Core Function 3 for eliminating and minimizing hazards to employees.

The EFCOG-ESCoP determined that a "one-size-fits-all" approach is neither desirable nor practical, however, they determined the installation of an AVT over a VTS is highly encouraged for absence of voltage testing. The installation and use of these devices presents unique

challenges that must be addressed by the equipment owner, system engineer and users. For new equipment installations, these devices should, when feasible, be included in the design specifications and installed by electrical equipment manufacturers as part of the equipment construction, reducing potential issues of field installation by the end user. The use of these devices is recommended and encouraged by the EFCOG-ESCoP, but the type of device installed is up to the end user.

The EFCOG-ESCoP is aware the devices illustrated above are not the only ones available and similar or better products are likely to be developed by manufacturers in the future. This guidance discusses two types of permanently mounted test devices as examples to show that installation of these devices will decrease personnel exposure to hazardous electrical energy. The installation and use of any permanently mounted test device should be evaluated by an electrical engineer to ensure that the device is suitable for installation in the equipment and is installed per the requirements of NFPA 70 “The National Electric Code” and NFPA 70E.

NOTE: *Electrical AHJ or delegate inspection and approval is required for all newly installed or modified electrical equipment or systems to ensure they comply with applicable installation codes and standards prior to being placed in service.*

The EFCOG-ESCoP recommends that the use of permanently mounted test devices for the purpose of performing absence of voltage tests to establish a safe electrical working condition be performed by a qualified and authorized worker who has been qualified with respect to the specific equipment or system.

Acronyms

AHJ – Authority Having Jurisdiction

AVT – Absence of Voltage Tester

EFCOG-ESCoP – Energy Facility Contractors Group – Electrical Safety Community of Practice

LO/TO - Lockout/Tagout

NRTL – Nationally Recognized Testing Laboratory

PPE – Personal Protective Equipment

PTI – Portable Test Instrument

UL – Underwriters Laboratories

VTS – Voltage Test Station