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DRAWING THE LINE – WHERE DOES TROUBLESHOOTING END AND 'WORKING ON' BEGIN?

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Abstract – Testing, troubleshooting and voltage measuring are exempted from the requirement for an Energized Electrical Work Permit. However, once the problem is determined, troubleshooting often segues right into repair and we find our craft performing repairs with equipment still in an energized state without an Energized Electrical Work Permit in place. Even more concerning than the lack of a properly executed Energized Electrical Work Permit is the fact that the repair work may not need to be performed in an energized state at all and an electrically safe work condition can be established before repairs begin.
This paper discusses where to draw the line between troubleshooting and 'working on' and provides suggestions for methodologies to better identify for the craftsman when the work has transitioned from troubleshooting to repair and de-energization of the equipment or implementation of the Energized Electrical Work Permit process is required.

Index Terms — troubleshooting, electrical safety program, management, cost, working on

I. INTRODUCTION

The NFPA 70E standard is quite clear with respect to the concept of establishing an electrically safe work condition and the steps involved in doing so. Article 130.2 states, in no uncertain terms, the requirement to establish an electrically safe work condition if one is within the limited approach boundary or the area where there is an increased likelihood of injury from an exposure to an arc flash. Article 120.5 delineates the eight steps for establishing an electrically safe work condition. The definition of electrically safe work condition is spelled out for us in Article 100. And yet, time and again, we find craft working energized when an electrically safe work condition should have been established.

While failure to establish an electrically safe work condition still occasionally occurs as a result of old style thinking, a lack of familiarity with NFPA 70E, or a general disinclination to take the NFPA 70E standard and its requirements seriously, a more common failure to establish an electrically safe work condition occurs in the troubleshooting environment. The most common method of troubleshooting is voltage measuring, making it infeasible to troubleshoot in a de-energized state. However, at some point the cause of the problem is determined, completing the troubleshooting phase of the process, and the repair portion of the process begins. It is at this point that we frequently find the craftsman continuing the repair process without first stopping to establish an electrically safe work condition.

II. TROUBLESHOOTING VS. WORKING ON

A. Terminology Clarification

As defined in Article 100, 'Working On' consists of "Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing."[1] The definition then goes on to differentiate between troubleshooting and repair; "There are two categories of "working on": *Diagnostic (testing)* is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment; *repair* is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.)."[2] More commonly in the field, the term "troubleshooting" is used to as opposed to "diagnostic" and the repair portion of the troubleshooting process is the part that is considered to be "working on", so for the purposes of this paper the term "working on" will not include the troubleshooting or diagnostic portion of the definition.

B. Troubleshooting Considerations

While Article 130.2 of the NFPA 70E requires the establishment of an electrically safe work condition, the article goes on to state in section A (2) that "energized work shall be permitted where the employer can demonstrate that the task to be performed is infeasible in a de-energized state due to equipment design or operational limitations."[3] Troubleshooting is commonly held to be one of those items that is infeasible in a de-energized state due to operational limitations and the informational note added in the 2018 cycle providing examples of work that might be performed energized as a result of infeasibility confirms that assumption.

It is worth noting that, while we rarely do it, troubleshooting can be performed in a de-energized state. Instead of measuring voltage to look for opens in a circuit, one can troubleshoot resistively. There are a couple of drawbacks to troubleshooting resistively. Conductors usually have to be lifted in order to troubleshoot in this fashion, since one cannot accurately measure resistances in parallel, so when using

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resistance for our troubleshooting methodology we are faced with ensuring we mark conductors accurately so we can re-land each conductor in its proper location. Additionally, as part of the re-landing process we must ensure that proper torque values are maintained and must consider that conductors may have already been deformed by the initial torqueing process. These drawbacks make troubleshooting energized by using voltage readings an attractive proposition despite the hazard presented by the fact that it is being performed on an energized circuit.

Additionally, while an Energized Electrical Work Permit is required for any energized work performed within the restricted approach boundary or when the possibility of exposure to an arc flash hazard exists, 130.3 of the NFPA 70E specifically exempts troubleshooting, along with testing and voltage measuring, provided the work is done by a qualified person using the appropriate safe work practices and PPE.

All of this leads us to an understanding that troubleshooting is something that is routinely performed in an energized state, without the requirement of an Energized Electrical Work Permit, provided appropriate safe work practices and PPE are put into place.

C. Working On

Other than the definition in Article 100, there is little in the way of further information provided throughout the Standard for the terminology "working on" with respect to repair of equipment. However, while Article 100 specifically defines "working on" to be any physical alteration of equipment, the term is frequently used in the field to be any action that "breaks the plane" at the face of the equipment. It could also be defined, for the purposes of this paper, as any work that involves the use of tools other than test equipment.

D. The Dividing Line

The Standard makes the dividing line between troubleshooting and "working on" abundantly clear. Troubleshooting involves the use of test equipment, "working on" involves the use of any tools other than test equipment. Troubleshooting is diagnostics, "working on", in the context used in this paper, is repair. Once the troubleshooting has determined the cause of the failure or problem in the equipment, the troubleshooting is complete and the separate task of repair begins.

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III. WHERE DO WE DRAW THE LINE?

It turns out the question is not really "Where do we draw the line?" but "Why do we continue to ignore where the line should be drawn?" Based on years of experience in the field, the author has several observations.

A. Custom

It is difficult for those of us involved in the Electrical Safety Workshop to recognize that in this day and age there are those who still have not heard of the NFPA 70E and its counterpart safety documents around the world, but unfortunately it is true. And there is another complement of the electrical craft population who may have heard of it peripherally but are not really aware of its content and, more importantly, the why behind the content.

For many workers, working energized is still routine and many craft move from troubleshooting to repair without de-energizing. As a safety community it is important that we continue to work to provide every worker who works in the presence of electricity a basic knowledge of the hazards of electricity and the measures one can take to protect themselves (de-energization, Energized Electrical Work Permits, PPE, etc.). We must do more to work with states and other Authorities Having Jurisdiction to ensure that training in the NFPA 70E and its counterparts throughout the world are provided to every electrical worker through trade schools, apprenticeships, and continuing education. As part of the move into an NFPA 70E environment, special focus needs to be placed on the Article 100 definition of Working On and special emphasis must be placed on the demarcation between troubleshooting (diagnosing) and repair.

B. Convenience

The transition from troubleshooting to repair involves either the implementation of an Energized Electrical Work Permit, if the employer can demonstrate that the work meets the criteria of additional hazard, increased risk, or infeasibility, or the implementation of the eight steps in Article 120.5 for establishing an Electrically Safe Work Condition. A break must occur in the process in order to implement either of these two options. In the get-it-done atmosphere of most commercial and industrial work environments, this break that is the transition from troubleshooting to repair is looked upon as a nuisance and an inconvenience by craft who make the argument that it will take more work to implement either of these options than it will just to complete the repair.

There are several steps that need to be taken to address this issue and mindset. The first is training. In addition to emphasis on the definition of 'Working On' and ensuring the dividing line between troubleshooting and repair is clearly understood and implemented there are other sections of the NFPA 70E standard that, when implemented, can assist with the transition from diagnosing to repair.

The starting point is the safety program itself as identified in Article 110.1(D) "The electrical safety program shall be designed to provide an awareness of the potential electrical hazards to employees who work in an environment with the presence of electrical hazards. *The program shall be developed to provide the required self-discipline* for all employees who must perform work that may involve electrical hazards."[4] The failure of craft to recognize" where the dividing line between troubleshooting and "working on" exists is a failure of management to adequately develop the safety program to the necessary degree.

Other sections of the standard that can assist in clarifying the demarcation between troubleshooting and Working On are found in Article 110.1(I) Job Safety Planning and Job Briefing.[5] The Job Safety Planning section requires that a job safety plan is documented (i.e. written) by a qualified person and include a description of the job and the individual tasks. In a troubleshooting scenario, it is impossible to detail the sequence that must be followed in order to identify the cause of the problem. The unknown of why the failure occurred is why troubleshooting is taking place in the first place. Only the

qualified craftsman in the field will be able to determine what the cause of the problem is. At the point at which the cause of the problem is determined, there is a change in scope (110.1(I)(3)), which requires additional job planning and additional job briefing. It is important that the initial job plan and briefing identify that once troubleshooting is complete, the transition into repair mode represents a change in scope that will require de-energization, additional job planning, and additional job briefing. This is accomplished in some organizations by requiring a separate work order for the repair work be created from the initial troubleshooting workorder. This methodology is also a very effective way for an organization to document troubleshooting time versus repair time if records are kept to that level of detail.

C. Expediency

Another area where difficulty can occur with respect to the craftsman knowing where to draw the line between energized troubleshooting and the need to de-energize for repair is when management sends mixed signals or the wrong signal. Even though committed on paper or in theory to a robust electrical safety program, the temptation to get a project done or pressure to get a piece of equipment back up and running can result in management ignoring or even "re-interpreting" the NFPA 70E standard to suit the perceived need of the moment. In addition to putting the craftsman at risk and sending the wrong message to craft personnel with respect to future work when it comes time to transition from troubleshooting to repair, management introduces cynicism into the workforce with respect to the commitment of the company to safety and undermines their entire safety program by not doing the right thing when the going gets tough.

D. OSHA Weighs In

One argument occasionally presented by employers or entities declining to implement or fully implement the NFPA 70E Standard is that it is just a standard. It is not a Code, it is not required by law, it is simply a consensus standard, not enforceable by an Authority Having Jurisdiction. However, this is the point where OSHA, which is federal law, comes into play. A Final Rule issued by the Department of Labor Occupational Safety and Health Administration states: "Therefore, OSHA is not leaving it to the employer's discretion as to whether or not to de-energize electric circuits on the basis of convenience, custom or expediency."[6] The rule then goes on to recognize the concept of increased hazard and infeasibility, just as stated in the current version of the NFPA 70E. In other words, when we don't make the proper transition from troubleshooting energized to repairing de-energized, we are not only violating the NFPA 70E, we are also violating OSHA.

IV. CONCLUSIONS

This paper describes the basic format and style for ESW papers. For additional information, contact the ESW Technical Committee Chair.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

[1] NFPA 70E, 2018 *Standard for Electrical Safety in the Workplace*, Quincy, MA: NFPA.
[2] ibid
[3] ibid
[4] ibid
[5] ibid
[6] Federal Register / Vol 55 / No 151 / Monday, August 6, 1990, / Rules and Regulations / Page 32000

VII. VITA

Wes Mozley is a systems electrical engineer responsible for a variety of systems and processes, including the arc flash program at Sandia National Laboratories in Albuquerque, New Mexico, where she has worked for over 38 years. Originally an electrician by trade, Wes worked primarily in industrial maintenance and construction in both medium and low voltage applications. In addition to carrying tools for many years, she has worked as a supervisor, inspector, designer, contract manager, quality engineer and maintenance engineer. Wes taught in the Electrical Trades department of Central New Mexico Community College for over 35 years and taught in apprenticeship programs for 14 years and has written curriculum for national apprenticeship programs. Wes also runs her own consulting firm providing electrical safety, maintenance and forensic consulting, safety and electrical training, and continuing education.