

EFCOG BEST PRACTICE # 211

Best Practice Title: Managing Hazards of Multiwire Branch Circuits Installed Before the 2008 NEC

Facility: DOE Complex

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Brief Description of Best Practice: Multiwire branch circuits installed under NEC editions earlier than 2008 may create unique hazards that are not readily identified during planning or implementation for a lockout. Upgrading these multiwire branch circuit installations to the requirements of the 2008 NEC or later edition eliminates this hazard. This Best Practice provides guidance for managing these hazards in facilities that have not been upgraded.

This guidance is intended only to address multiwire branch circuits, not the greater subject of shared neutrals. However, some of the techniques contained in this document may also be useful for identifying shared neutrals in legacy non-code compliant situations that are not multiwire branch circuits.

Why the best practice was used: The Best Practice is used to reduce risk of shock by using precautions to identify a multiwire branch circuit.

What are the benefits of the best practice: This Best Practice provides guidance for identifying a multiwire branch circuit and precautions for working with neutral conductors that are part of a multiwire branch circuit.

What problems/issues were associated with the best practice: No consistent guidance regarding the hazards of multiwire branch circuits installed before the 2008 NEC.

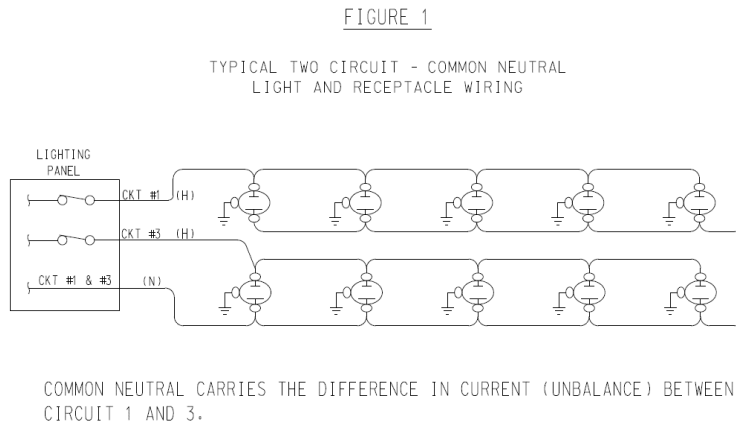
How the success of the Best Practice was measured: Success is measured by the reduction in electrical events resulting from discoveries of hazardous voltage associated with multiwire branch circuits. Metrics should be considered at the site level to track the effectiveness of this guidance.

Description of process experience using the Best Practice: These practices have been used successfully at multiple sites to identify multiwire branch circuits when replacing lighting ballasts or fixtures in older facilities.

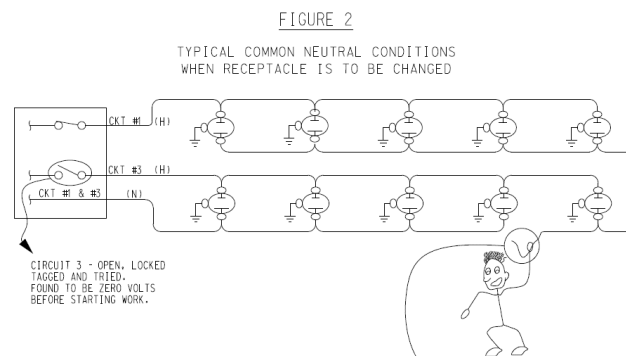
Managing Hazards of Multiwire Branch Circuits Installed Before the 2008 NEC

Multiwire branch circuits can pose unique hazards that may not be readily identified during planning or zero energy checks. Multi-wire branch circuits are often referred to as an Edison circuit or as circuits having a “shared” or “common” neutral circuit. This is not a good practice, because there are many instances where neutrals are shared, usually non-code compliant that are not multiwire branch circuits. This paper only addresses the multiwire branch circuits and not the greater subject of shared neutrals.

This best practice provides methods and work practices to help manage and protect workers from the risk of a potential shock unique to multiwire branch circuits. Multiwire branch circuits are typically used on 120/240 volt single phase systems as well as 208Y/120 and 480Y/277 volt three phase systems. Multiwire branch circuits use a “shared” or “common” neutral that carries the unbalanced current (Figure 1).



Breaking or opening the "shared" neutral while it is carrying unbalanced current can create an unsafe condition because the line voltage appears on the lifted lead. A person who touches the lifted or broken neutral lead, places their body in series with the hot lead, the load, and ground and could receive a severe electrical shock (Figure 2). The only sure way to prevent a potential electric shock from unbalanced current is to open all circuits that share this neutral conductor.



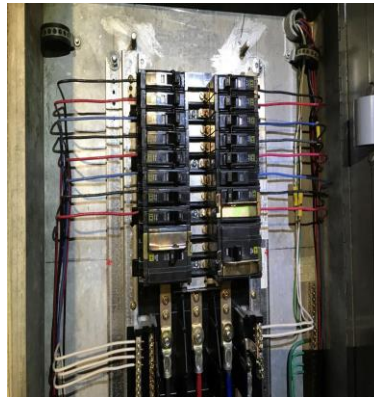
The National Electrical Code (NEC) recognized this unique hazard and introduced a new requirement in 2008 to group and simultaneously disconnect all ungrounded conductors (e.g., breaker handle ties) on a multiwire branch circuit. Installations before 2008 will often have multiwire branch circuits installed without these handle ties and may not have used branch circuit “pigtailed” at devices as required by NEC 300.13(B) in earlier editions. Multiwire branch circuits installed prior to the 2008 NEC edition should be considered suspect unless they have been field verified.

This document provides guidance to reduce risk of exposure when working on or isolating a multiwire branch circuit that has not been verified or installed with handle ties.

Indications of a Multiwire Branch Circuit

Workers should be trained to recognize indications that a multiwire branch circuit may be present. Indications of multiwire branch circuits may include the following:

1. More ungrounded conductors (e.g. red, blue, black) than neutral conductors (e.g., white insulated conductors) in a panelboard or terminal box



2. Multiple neutral wires connected under a single wire nut¹. (The picture below shows a device connected with a “pigtail” per NEC 300.13(B) to maintain continuity of the neutral when replacing the receptacle.)



¹ This is a requirement of NEC 300.13(B) for multiwire branch circuits. The neutral from the multiwire branch circuit is “pigtailed” at a device so the disconnection of the device will not interrupt the continuity. This requirement has been in the code since at least the 1971 edition.

3. Special marking on ungrounded conductors
4. Panelboards with single phase breakers (e.g. 120/240V single phase, 208Y/120V, 480Y/277V)
5. Disconnecting a neutral conductor causes an unanticipated circuit to de-energize or erratic operation
6. Manufacturers handle ties or field installed ties between single pole breakers



7. “Multiwire Branch Circuit” caution labels installed on panelboard or breakers



8. A branch circuit cable or conduit enters a panel with more ungrounded conductors than neutral conductors, and the ungrounded conductors terminate at single pole circuit breakers.

Work Planning and Practices

1. Train workers to recognize and understand the potential hazards with multiwire branch circuits. One excellent training presentation developed by Fluor Hanford is available on the EFCOG page, “Potential Hazards with Neutral Conductors”.
2. Review facility lighting and receptacle plan drawings during the work planning phase to determine if multiwire branch circuits were used. Some of the older site lighting and receptacle plan drawings show the number of circuits and wires in a conduit. Where two wires are not shown for each circuit in a conduit or raceway, a common neutral should be suspected. Some drawings designated multiwire branch circuits using circuit numbers with slashes across lines to indicate number of ungrounded conductors (e.g. some drawings use slash lines to indicate ungrounded conductor and longer lines for neutral conductor- count the number of short lines versus long lines).
3. Perform a field walkdown during work planning and determine if panelboards have single pole breakers only and no handle ties exist.
4. Provide instructions and cautions in work packages to deal with multiwire branch circuits to remind workers to be alert and use proper work practices to identify all circuits.
5. Discuss indications and actions for handling multiwire branch circuits in pre-job briefings.
6. Open panel or box covers in accordance with work procedures and look for signs of multiwire branch circuit at the specific location where you plan to break the neutral. If each black or ungrounded wire entering or exiting the location does not appear to have a dedicated white wire associated with it, a multiwire branch circuit should be suspected and lockout/tagout all circuits for work to be performed.
7. Maintain the continuity of the neutral, if possible, by only breaking the single white wire that connects to the device being worked on. Multiwire branch circuits are required by code to be wired with a wire-nut or crimped pigtail type connection (NEC 300.13(B)). You only need to break the single lead to the device from the wire-nut or crimp connection; the neutral circuit is maintained back to the source location and prevents the potential for voltage on the neutral lead that connects to the device.
8. If the neutral is wired through the device and not connected using a pigtail² (i.e. there is more than one white neutral wire connected to the device), then caution should be exercised. Prior to lifting or breaking the neutral lead, use appropriate PPE in accordance with procedures and perform an “absence of current” test with a proximity current detector (e.g. the Extech DVA30 or equivalent) and/or a clamp-on ammeter. If

² This is a violation of NEC 300.13(B)

current is detected, work should be paused and the circuit investigated to ensure all ungrounded conductors have been isolated.

CAUTION: This technique should be used with caution since current will only flow on the neutral circuit if one or more of the circuit(s) sharing the neutral has a load energized at the time the measurement is taken. If the load on the other circuit is “off” during the measurement, the current detector will not indicate a “shared” neutral even though the load could be switched “on” later.

9. Where neutral leads (i.e. more than one) must be un-spliced or removed or lifted from a device, measure for absence of voltage to ground immediately after the leads have been lifted. Don dielectric PPE when breaking the neutral and testing for voltage. Consider separating and insulating each wire individually prior to removing PPE since the testing for current as provided in #8 above can only detect a “shared” neutral when load on the other circuit is “on”. (Note: Don PPE again to re-make the splice if necessary.)
10. If voltage is found after lifting a neutral lead, stop work, notify supervision and develop a plan to determine the circuit supplying the voltage. After opening additional circuits or the main disconnecting switch/breaker for the panel, recheck for voltage. Caution: In rare cases, the neutral may have been tapped from a different panel.
11. Correct the shared neutral hazard, if possible, by installing crimped pigtails or other means, to maintain continuity of the neutral wiring. Revise panel schedules and drawings to indicate same. Connect breakers with handle ties, if possible, such that opening one of the circuits will de-energize all circuits that are part of the multiwire branch circuit.
12. Label panels that are found to have multiwire branch circuits without handle ties. See example of a label above in #7.