WHITE PAPER:

WIRING PRACTICES & TROUBLESHOOTING WITH AFCIs

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
Low Voltage Distribution Equipment Section

As technology continues to become more and more advanced with each passing day, it's more important than ever that good wiring practices be followed to ensure safe and trouble-free electrical distribution installation, as well as to experience the significant safety benefits today's technology promises. The Arc Fault Circuit Interrupter (AFCI) -- the next generation in circuit breaker technology -- is one such life-saving tool that has been steadily expanding with each National Electrical Code cycle.

Unlike a conventional circuit breaker, which detects overloads and short circuits, an AFCI utilizes advanced electronic technology to "sense" different arcing conditions. Common household items, such as a motor-driven vacuum cleaner and a furnace motor, naturally create arcs when they are operating. Each of these conditions is considered a normal arc, which can also occur when a light switch is turned off.

Arc faults, however, may result from damaged wiring, overheated or stressed electrical cords, worn electrical insulation, wires and/or cords in contact with vibrating metal, damaged electrical appliances and more. This potentially dangerous condition creates high-intensity heat – which may exceed 10,000 degrees Fahrenheit – resulting in burning particles that can easily ignite surrounding material, such as wood framing or insulation.

AFCIs are designed to recognize arc faults when they occur and automatically shut the circuit down before it becomes a fire hazard. Manufacturers of AFCIs test for hundreds of possible operating conditions, and design each AFCI to constantly discern between normal and dangerous arcs.

Due to the proven effectiveness of AFCIs, it is important that proper wiring practices be followed to minimize troubleshooting efforts and to ensure homeowners benefit from the proven, life-saving capability of the device. The following sections highlight some of the basic wiring practices electricians should follow during electrical installation projects, especially those performed on circuits that will be protected by AFCIs, as well as appropriate steps to successfully troubleshoot a potential wiring problem that will cause the AFCI to trip.

Safety First

The first step in any electrical installation project is to recognize potential safety hazards. Exposed electrical parts, worn insulation on wires and extension cords, lack of grounding of equipment and electrical infrastructure, overloaded circuits, moisture in the work area and other potential hazards should be properly evaluated before any electrical work is to be conducted. For example, a tripped AFCI circuit breaker points to a potential problem that should be investigated to determine the exact cause of the trip.

Electrical connections that feel warm, appear damaged or have a burning odor should be reviewed closely to determine the best course of action.

Upon correct evaluation, turn the breaker off, isolate the problem and remove any dangerous conditions before attempting any additional electrical work. If needed, notify qualified safety experts to assist in safeguarding the work area.

A great rule of thumb is to treat every wire as if it is energized. A circuit may not be wired correctly. For example, wires may contact other hot circuits, creating a potential dangerous situation.

Proper Tools & Practice

Using the right tools to do the job is very important. A simple task such as drilling holes in studs, if done incorrectly, can jeopardize the integrity of the insulation of the wiring being pulled. Damaged conductors during installation could result in immediate tripping of the AFCI when the circuit is energized. Once you select the right tools for the job, it's important you properly maintain them. It's best to replace worn tools in order to decrease the risk of damaging wires or insulation.

For example, simply changing the blade in a razor blade knife can not only prevent needlessly damaging conductors, but also increases the safety of performing the task. Keep in mind, if you nick a wire or accidentally remove strands from a conductor, there is less copper to carry the same amount of current, resulting in overheating and possibly further damage to the installed wiring. An ounce of prevention can go a long way saving hours of troubleshooting after the fact. These same conductors, if damaged due to poorly maintained tools, will eventually be hidden by drywall and paint preventing easy identification of the cause of an AFCI tripping.

Selecting proper equipment and de-rating conductors is as much a part of circuit protection as the application of the circuit breaker itself. Make sure you select the right conductor and right wiring device for the application. Additionally, pay attention to ampacity, interrupting ratings and other important factors. De-rating of conductors when necessary, making ambient and other adjustments, is all a part of those necessary steps that could help you avoid a call back to a job and avoid the hours of troubleshooting necessary to remedy the situation.

Protecting the conductors and other wiring devices from the environment in which they are placed is also important to avoid hours of troubleshooting. Simply placing nail guard plates in those areas where the likelihood of a future tradesperson to nail a trim, secure a cabinet, or other item to the wall could save

the wire from being damaged and save you hours of work when the AFCI detects the problem. Choosing where to drill your holes through the studs and joists can save the money in nail guards. For example, knowing that kitchen cabinets will be installed on a wall and knowing how high up on the wall those cabinets are located can help you determine where to route your wires ensuring they are out of the danger zone.

Ensure your employees know your standard practices. Setting guidelines and communicating them to your electricians can help you identify possible problems later. Making sure you have properly trained individuals performing even the most menial of tasks will help get you closer to the goal of having your AFCIs hold the first time and every time they energize the circuit.

Project Planning

It is important to remember that you are not the only trade that will be working on the home being built. Other trades will come before and after your work is completed, and those working around your electrical installation can jeopardize it, causing you hours of troubleshooting. Timing when your work is being done can avoid unnecessary damage to the conductors you have installed and avoid costly troubleshooting hours. In a typical home construction, plumbing and HVAC trades should have completed their work before you starting pulling wire. After you have roughed in your installation, drywall, cabinets, trim and other fixtures will be installed.

Understanding this process and the timing of construction elements can help reduce, if not eliminate, troubleshooting due to other trades damaging conductors, wiring devices and any other electrical component you install. You can make the right decisions on where to route wiring and what preventative measures need to be taken to ensure that a nail or screw won't penetrate or nick electrical wiring behind walls. A nicked wire, if left uncorrected, will trip an AFCI, so installing electrical wiring around the installation of HVAC duct work and water supplies and drains, will help avoid any future repairs that arise from such damage.

The plumbing trade has a task of installing tubing, copper or other materials throughout the home. They may use propane and/or other heat operating items that can melt and severely damage wire if they are performing their work after you have already pulled your wire. Performing your electrical work after the plumbing trade has completed its work will not leave you wondering if the heat from their torches damaged any of your wiring.

The HVAC installation is yet another area of concern. Ductwork must be installed throughout the home, through joists and through studding. When your electrical wires are in the way, it may seem

harmless, but pulling on and tugging to push ductwork between the wire and the floor may occur. Sharp edges of the ductwork can damage insulation as it is pushed past your wiring. This is avoidable through proper scheduling and timing.

Making safety a priority, using proper tools and planning your project accordingly will help in the correct installation of the circuits that AFCIs protect and prevent the potential issues that may cause them to trip. In the event of tripping, there are specific steps you can take to diagnose and troubleshoot the problem.

AFCI Installation

Install the breaker and connect the pigtail to the neutral bar. Reset the breaker if necessary and turn it ON. Press the test button. The breaker should trip. Turn the breaker OFF. Connect the load hot (black) and neutral (white) wires to the breaker. Turn the breaker ON. It should not trip. If it does, see AFCI Troubleshooting below.

Avoid common wiring mistakes such as connecting the load neutral (white) wire to the neutral bar rather than the neutral terminal on the breaker and sharing neutrals or grounding the neutral somewhere in the system.

AFCI Troubleshooting

The *National Electrical Code* (*NEC*®) requirements for AFCI installation in new home construction have expanded with each code cycle. AFCIs first appeared in the 1999 edition of the *NEC*®, which required their use in branch circuits that supply power to receptacle outlets in bedrooms of homes. After further research and analysis of the technology and its potential safety benefits, the 2002 *NEC*® expanded its requirement for AFCIs to also include all bedroom circuits, including those that supply lighting fixtures, smoke alarms and other equipment. The 2008 edition of the *NEC*® took safety a step further by requiring that all new home construction install the technology on other circuits in the home.

The 2008 *NEC*® reads:

***2008** NEC® —210.12 – Arc-Fault Circuit-Interrupter Protection*

(B) Dwelling Units. All 120-volt, single phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit in family rooms, dining rooms, living rooms, parlors, libraries, dens, sun rooms, recreation rooms, closets, hallways, or similar rooms or areas shall be protected by a listed arc-fault circuit interrupter, combination type installed to provide protection of the branch circuit.

An AFCI trip alerts the homeowner or electrician of a potential problem in the electrical wiring that, left uncorrected, could potentially lead to an electrical fire. Opponents who believe AFCIs are not needed raise concern over "unwanted" tripping. However, consistent findings have revealed that the majority of what are referred to as "unwanted" trip issues are, in fact, related to problems with the installed wiring or attached wiring devices.

Examples of the issues that AFCIs find include reversing neutral and ground wires, shared neutral wiring on single pole AFCI circuits and ground wires touching neutral wires. Lighting fixtures and appliances attached to these circuits have also been found to be damaged or faulty and should be inspected if an AFCI trips.

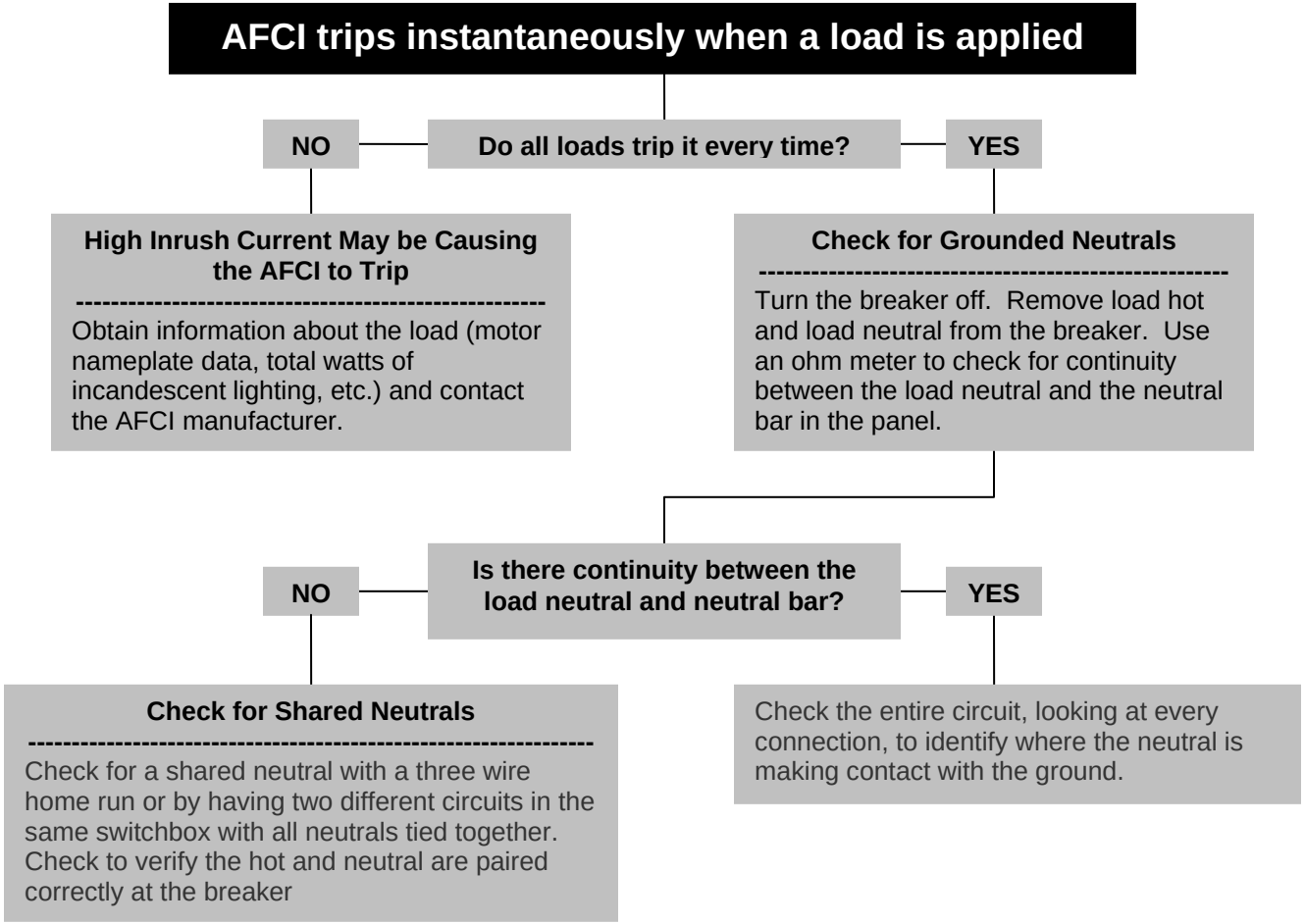
Electrical contractors have been very active in providing information about these types of wiring problems. Many indicate that the initial installation errors have disappeared as installers become more familiar with the installation and operation of AFCIs.

AFCIs trip for a reason, and investigating and determining the reason will ultimately increase the safety of homeowners and their families. The troubleshooting guide on the following pages outlines common scenarios and the appropriate steps to diagnose and effectively alleviate any issues.

AFCI TROUBLESHOOTING GUIDE

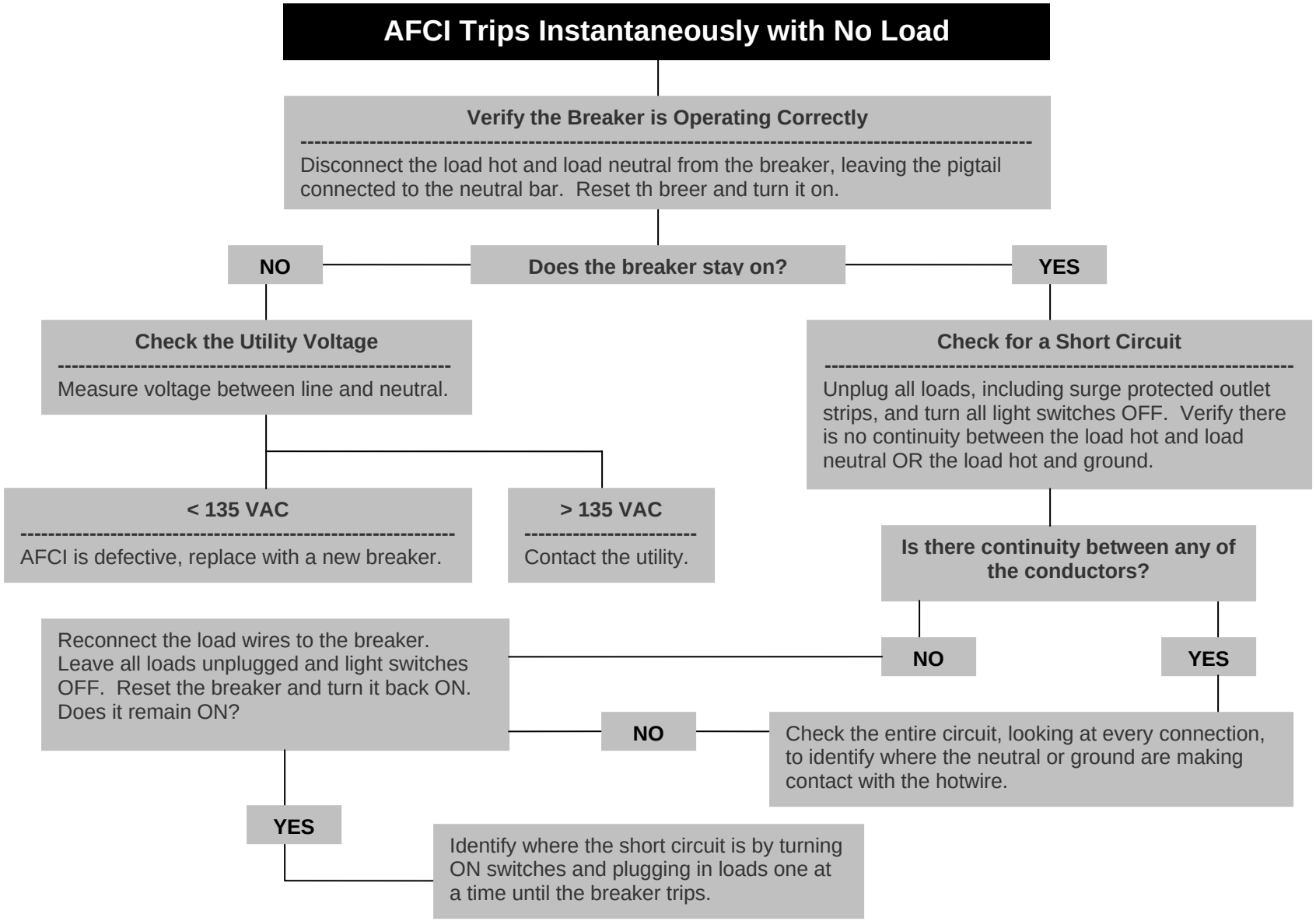
AFCI trips instantaneously when a load is applied

Instantaneous tripping is defined as a trip that occurs immediately after a load is applied while the handle of the AFCI is set in the ON position. The following process outlines the steps to troubleshoot this problem.



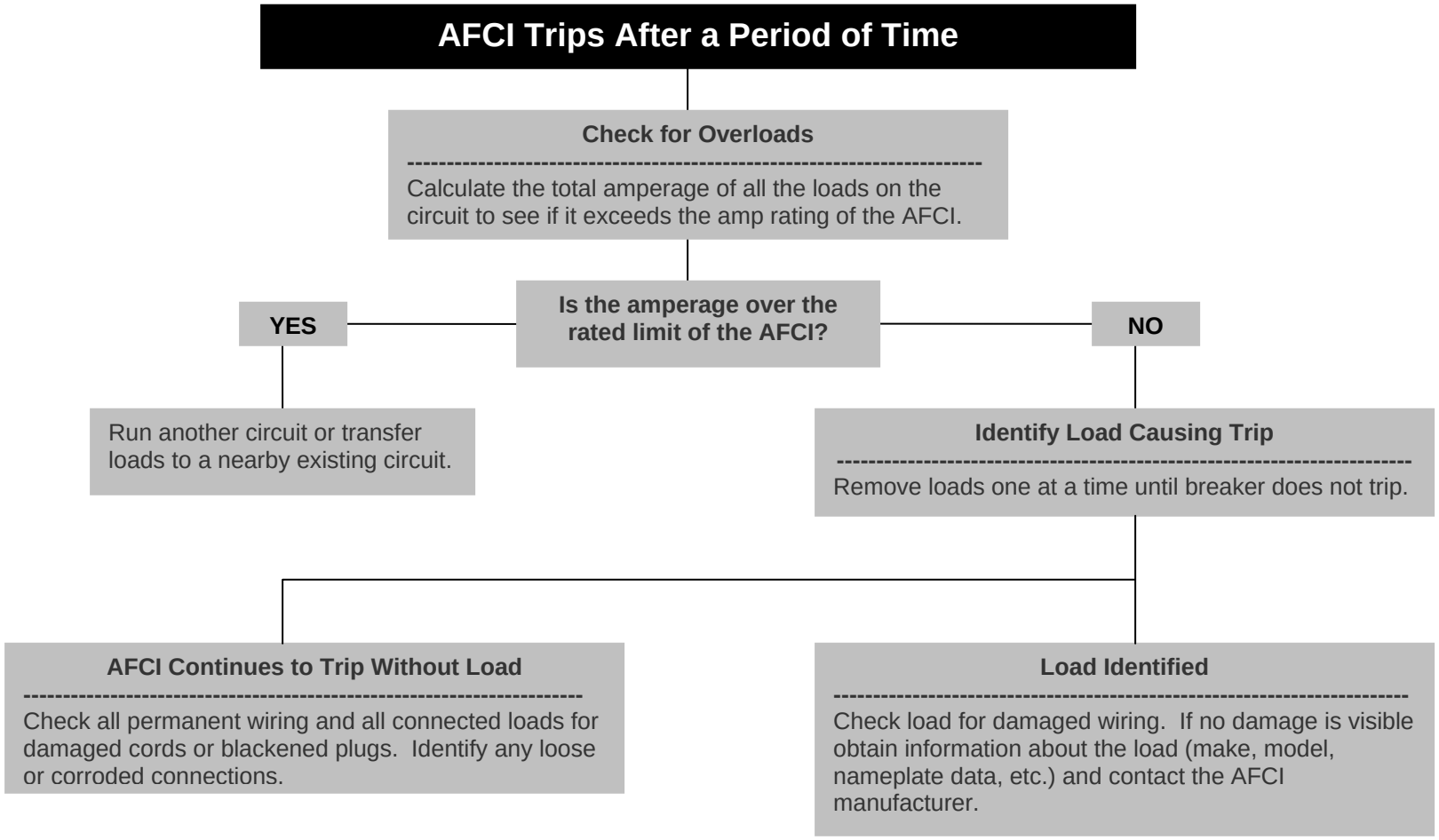
AFCI trips instantaneously with no load

No load on the AFCI is when the black conductor, the hot wire, is disconnected from the load terminal of the AFCI. The following process outlines the steps that should be followed when an AFCI with no load instantaneously trips.



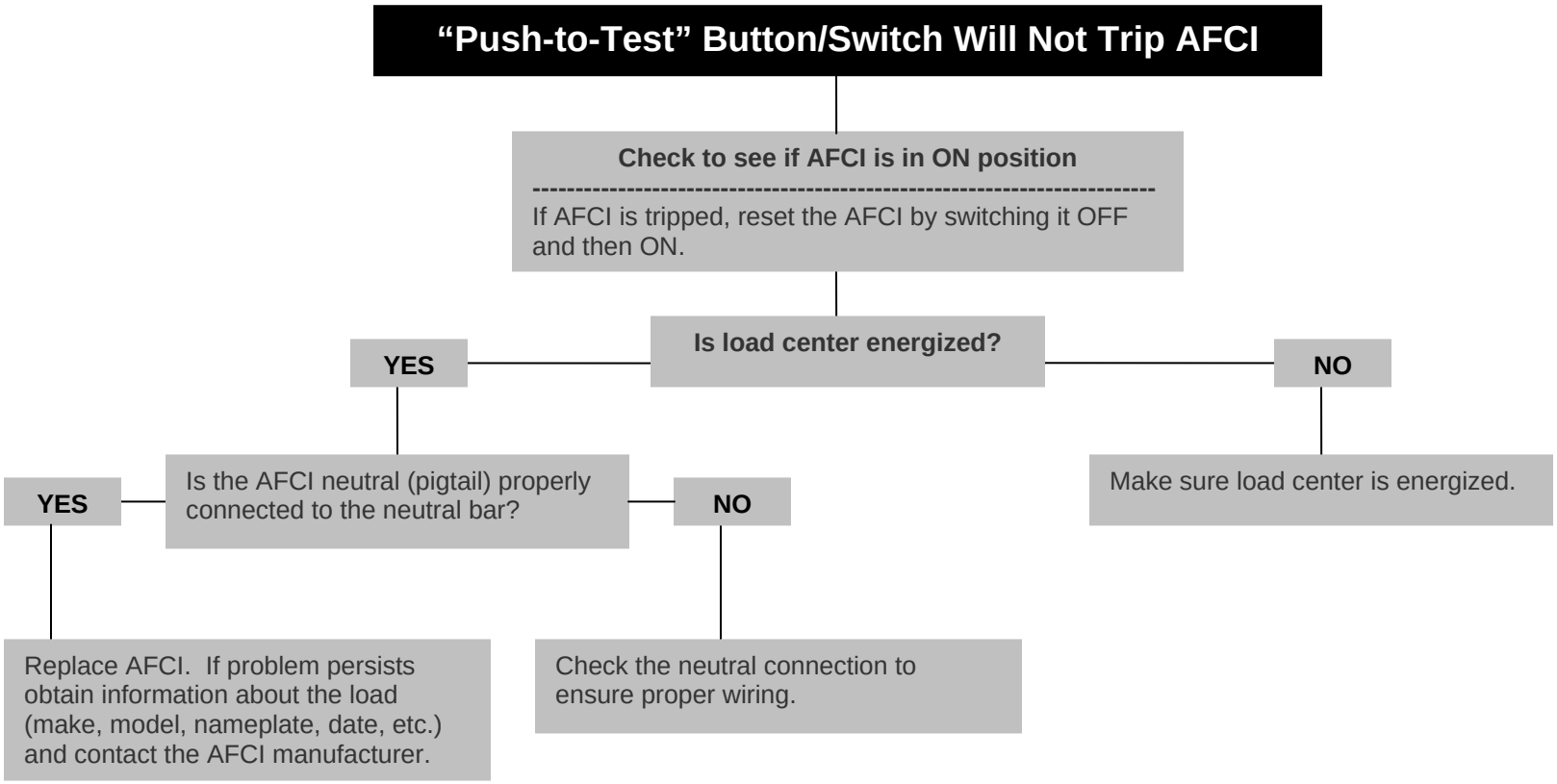
AFCI trips after a period of time

In some instances, the circuit or a load may appear to be causing the AFCI to trip after the circuit breaker has been in operation, in the "ON" state, for some length of time. The following procedure will help work through one of the most difficult instances there is to troubleshoot.



"Push-to-Test" Switch Will Not Trip AFCI

The following process outlines the steps that should be followed when the AFCI's "push-to-test" button does not trip the breaker.



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