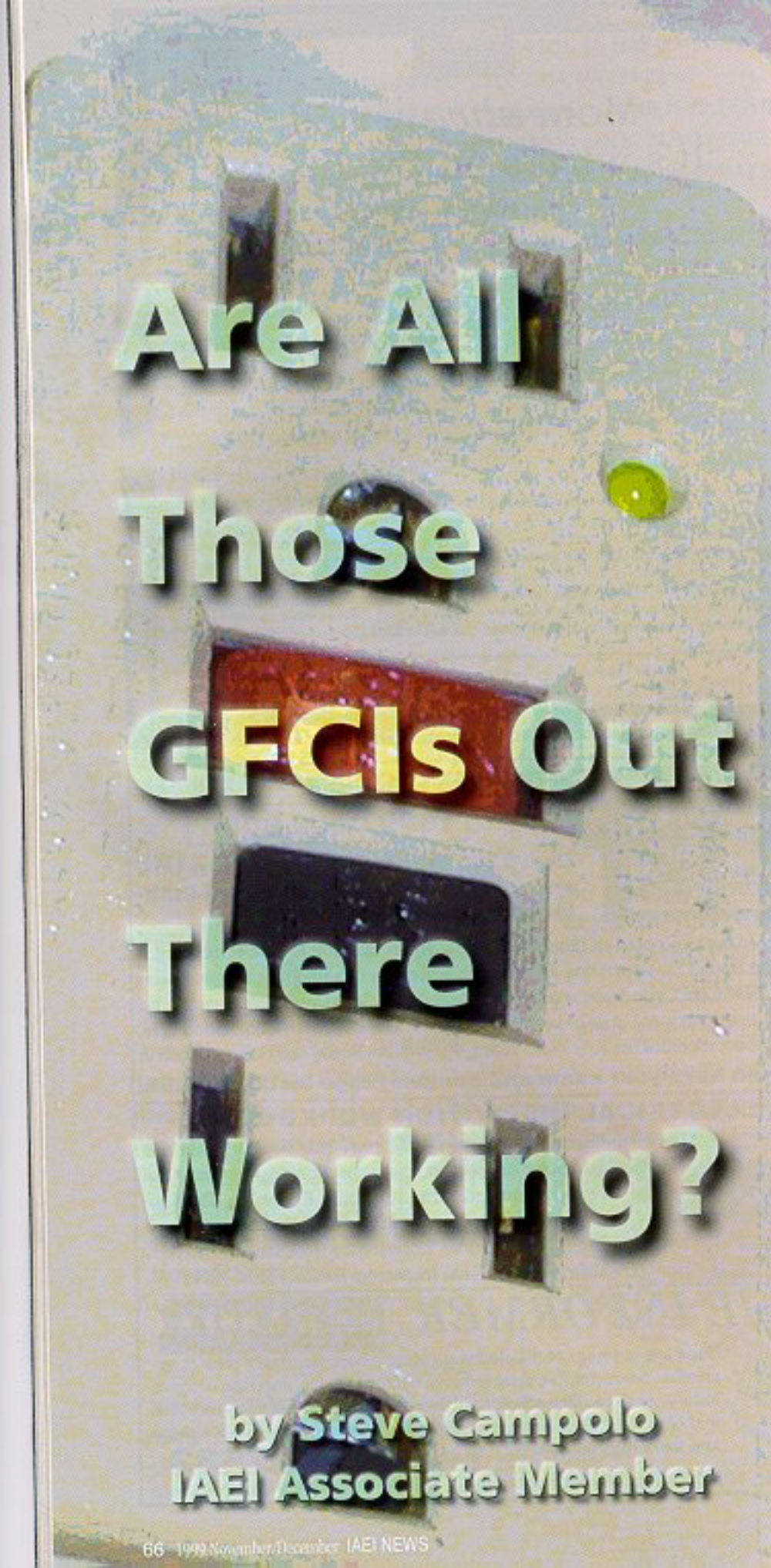

Are All Those GFCIs Out There Working?

by Steve Campolo
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Ground-fault circuit-interrupter (GFCI) protection is required in various locations by the *National Electrical Code* (*NEC*), NFPA 70. The *NEC* does not specify whether the GFCI should be a circuit breaker type or a receptacle type. Since the early 1970's the proliferation of GFCI installations has grown in leaps and bounds, providing an increase in the safe use of electricity. But what if the GFCI isn't working when it is called upon? That is, would *all* installed GFCIs trip when a ground fault occurs? This article will present recent data from the field in order to answer that question. Additionally, since arc-fault circuit-interrupters (AFCIs) are soon to be required by the *1999 NEC* Section 210-12(b) and will be installed in bedroom circuits of dwelling units effective January 1, 2002, comparable findings can be predicted for them.

When the product standard for GFCIs (UL-943) was first established, it was recognized that this safety device does not have an unlimited life, and a provision must be made to check its operation. For this reason, test and reset buttons were required, along with a warning to "test monthly." Nevertheless, if the device did not test, it could be reset to continue to furnish electricity, and the user would then be assumed to take greater care in using that circuit and replace the product at their convenience. Unfortunately, not all users are conscientious in this respect.

Survey of GFCI Operability

The data was accumulated by enlisting the services of home inspectors. These inspectors were members of the American Society of Home Inspectors (ASHI). Some inspectors were licensed professional engineers (PE's), others were former homebuilders. All had qualifications as encouraged by ASHI. The inspectors were selected from the various geographic areas of the United States. Special care was taken in selecting inspectors from prominent lightning areas in several states. The inspectors were asked to review at least 1000 of their past reports and provide the following data:

1. Age and location of the home.
2. Did the home have GFCIs?
3. Were the GFCIs tested as part of the home inspection?
4. How many worked and how many did not work?

GFCI CIRCUIT BREAKER FIELD STUDY

Location	# of Bldg. Sites	# of CB GFCI's	Inoperative GFCI CB	
			#	%
Nassau & Suffolk Counties **New York**	3121	203	23	11.3
Miami, Ft. Lauderdale, Hollywood, Boca Raton, Pembrook Pines **Florida**	1297	304	71	23.4
Dallas, Waco, Temple, Houston **Texas**	1000	86	31	36.0
Chicago Suburbs **Illinois**	1015	189	18	9.5
Napa, Vallejo, Vacaville, Fairfield, Davis, St. Helena **California**	1004	93	16	17.2
Seattle, Tacoma, Kent, Maple Valley **Washington State**	943	46	5	10.9
Seattle, Bellevue, Renton, Kirkland, Mercer Island, Redmond **Washington State**	2000	50	11	22.0
Sanibel Island, Naples, Fort Myers **Florida**	1000	79	46	58.2
Greater Skokie Area **Illinios**	1000	458	12	2.6
Chicago Proper **Chicago**	1000	75	13	17.3
TOTALS	13380	1583	234	20.8

Illustration 1

Illustration 1, entitled GFCI Circuit Breaker Field Study capsulizes the data. Out of 13,380 inspection reports, 1,583 GFCI circuit breakers were encountered, and 20.8% or 234 of them did not work when tested; that is, protection was not available. Illustration 2 (page 68) depicts the summary of the similar receptacle study. Out of 5,308 reports, 4,585 receptacles were encountered, and 19% or 878 GFCI receptacles did not work when tested. It is important to note that in the high lightning areas like Florida and Texas, inoperative GFCIs were found to be as high as 58.2%.

Product Improvements

In a 1994 speech, U.S. Consumer Product Safety Commission (CPSC) Chairman Ann Brown recounted several issues of concern. The first issue was GFCIs. Commissioner Brown said, "First of all, ground fault circuit interrupters. These devices are terrific, but they're useful only when they work." Chairman Brown further augmented her position on GFCIs at a reception of the National Electrical Safety Foundation (NESF) on June 8 of this year, "In one of the very first speeches I gave as chairman," she said, "I asked NEMA to make GFCIs better. I wanted consumers to be able to check to see if a GFCI was installed and working correctly." Partially based on Chairman Brown's challenge, the GFCI industry through the National Electrical Manufacturers Association (NEMA), Underwriters Laboratories (UL) and the CPSC, worked towards an answer to the challenge.

An interim solution, necessitating changes in the UL Standard resulted in a simpler, easier to read set of standard instructions and a warning label further instructing correct installation practice. One manufacturer recently added an indicator light to alert of incorrect installation. These solutions still would not answer Chairman Brown's concern of GFCIs being "useful only when they work."

Experience has shown that voltage surges due to utility switching, lightning strikes or other transient phenomena were the cause of a good many failures of GFCIs and other electrical equipment. An interesting factor is that the surges responsible for damaging a GFCI also caused the GFCI to trip. The natural assumption that users were resetting these damaged GFCIs was considered. After a damaged GFCI was reset, power could be delivered without GFCI protection, just like an ordinary receptacle. Perhaps users were not testing their GFCIs after such an event, or if they were tested, the information was ignored. The natural tendency may have been for the user to assume that if the power returns, all is well.

With that in mind, Leviton developed a GFCI that could not be reset if it were not functioning. In other words, the test for operation was included in the reset function and the device would bar the use of electricity on that circuit, requiring replacement of the product. Mr. William King, Jr., division director of electrical engineering said, "The new Leviton receptacle GFCI is a major step forward for improving the electric shock protection provided by GFCIs. The CPSC technical staff encourages Leviton to make this improved GFCI technology available so that greater protection against electrocution can be realized." This product is now listed by UL and will be marketed shortly.

GFCI RECEPTACLE STUDY

Location	# of Bldg. Sites	# of Receptacle GFCI's	Inoperative GFCI Receptacle	
			#	%
Miami, Ft. Lauderdale, Hollywood, Boca Raton, Pembrook Pines **Florida**	1297	1812	421	23.2
Dallas, Waco, Temple, Houston **Texas**	1000	432	79	18.3
Seattle, Tacoma, Kent, Maple Valley **Washington State**	943	960	67	7.0
Sanibel Island, Naples, Fort Myers **Florida**	1068	706	231	32.7
Greater Skokie Area **Illinios**	1000	675	75	11.1
TOTALS	5308	4585	878	19

Illustration 2

To further the increase in safety, suggestions to UL were made to write standards requirements that would add these new features to the GFCI Standard, UL-943, as well as to the newly printed AFCI Standard, UL-1699. These requirements would apply to receptacle GFCIs and to circuit breaker GFCIs. Additionally, the same requirements should be applied to AFCIs of all types. In early August, UL issued two bulletins to the GFCI and AFCI industries giving language to the requirements. The deadline for comments is September 30, 1999, and all interested parties are encouraged to respond.

Conclusion

It seems that lightning and/or voltage surge may be at the bottom of the GFCI damage issue. The data shows high correlation between damaged GFCIs and high lightning activity areas. The data also seems high even in lower lightening activity areas. Lightning and/or voltage surges have been around a long time and are sure to continue. Fortunately, GFCIs and AFCIs are tested for resistance to voltage surges. It has been suggested that the level of voltage surge testing could be raised in an effort to overcome the damaged electronics of these devices. On the surface that sounds logical and prudent; however, what if the new level of testing is not high enough? Another study ten years from now is sure to result. Also, and perhaps more importantly, the built-in surge protectors within GFCIs and AFCIs do not last forever.

Most electronic products like GFCIs and AFCIs utilize a metal oxide varistor (MOV) as a surge suppressor built into the product. Additionally, many surge suppressor panels, receptacles and power strips also utilize MOVs as the suppression element.

MOVs are grouped by their voltage rating and energy handling ability. The voltage surge energy is absorbed by the MOV and converted into heat. Repetitive, high-energy surges have been reported to degrade MOVs. Additionally, it has been suggested that the degradation is cumulative over time. For this reason, it is hoped that the simple approach explained above will be adopted. That is, if the GFCI or AFCI cannot complete its built-in test sequence, power should not be restored. Although this is a radical departure from the operation of existing GFCIs and AFCIs, it requires only minor changes to existing products.

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Steve Campolo is presently employed by Leviton Manufacturing Co. Inc. and is vice president, Engineering-Testing, Standards and Certifications. He has been with Leviton over 18 years. He has prior experience at Underwriters Laboratories, Dayton T. Brown Laboratories and others. His education includes a masters degree from Long Island University, bachelors degree from New York Institute of Technology and an associates degree from Suffolk County Community College. Mr. Campolo serves on Code Making Panel 17, of the NEC. He also serves on the UL Industry Advisory Group for Transient Voltage Surge Suppressors, Flexible Cords, Appliance Leakage Circuit Interrupters, Electronic Controls, Arc Fault Circuit Interrupters and others. He is also chairman of the NEMA Technical Committee for flexible cords.