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INVESTIGATE THE WORKING PROCESS OF GROUND FAULT CIRCUIT INTERUPTER

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ABSTRACT

The objective of this study was to ascertain the capabilities and limitations of the Ground Fault Circuit Interrupters (GFCI) used on Corps of Engineers (COE) supervised construction sites. Laboratory tests were conducted to determine , if GFCI samples from different manufacturers met the trip threshold design specifications of 5 mA + . if condensation, hot-cold environment, vibration, and RF, UHF and microwave fields adversely affected their operation. A limited field survey of COE supervised construction sites was conducted to evaluate the actual application of the GFCI. This survey included trip threshold measurements and discussions with COE and contractor personnel after nuisance tripping had occurred. While the GFCI is susceptible to same types of environmental degradation, continued use on construction sites is recommended. The results of laboratory and limited field study indicate that the present GFCI unreliable when used in construction environment where there could be high condensation, RF, UHF, microwave, and switching noise fields.

KEYWORDS

Adjustable speed drive, ground fault circuit interrupter, electromagnetic compatibility.

I. INTRODUCTION

A ground fault circuit interrupter (GFCI) is a device whose function is to interrupt the electrical circuit to the load when a fault current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protection device of the supply circuit." This definition first appeared in the 1958 National Electric Code (NEC) and was one of two specific methods suggested to protect against shock hazards caused by underwater lighting fixtures used in swimming pools. Figure 1 is a block diagram of a typical GFCI. The purpose of the GFCI is to protect persons from serious or fatal shock by limiting the time duration of the shock. (Available GFCIs reportedly operate within 1/40 of a sec). The GFCI is designed to trip below the "let-go" current threshold, which is defined as the maximum current at which a person is still capable of letting go of the source causing the

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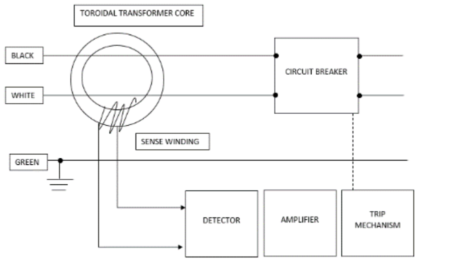
shock by using muscles directly stimulated by the current.

II. GFCI

A **ground fault circuit interrupter** is a type of circuit breaker which shuts off electric power when it senses an imbalance between the outgoing and incoming current. The main purpose is to protect people from an electric shock caused when some of the current travels through a person's body due to an electrical fault such as a short circuit, insulation failure, or equipment malfunction. Standard circuit breakers shut off power when the current is too high, like 10, 15, or 20 amps, but a mere 0.030 amps through a body can cause paralysis of skeletal muscles and stop the human heart. The GFCI breaks the circuit when it detects an imbalance of only 0.005 amps. A circuit breaker protects the house wires and receptacles from overheating and possible fire. It protects people and is often found in bathrooms or kitchens where electrical devices are used and people's bare flesh may be in contact with the floor or metal which provide an alternate path for current to travel in the case of an electrical fault. A GFCI can also prevent fires from short circuits and other electrical faults that don't involve humans such as a low current short where the current never reaches the trigger point for a circuit breaker.



III. DEVICE OPERATION

The GFCI consists of a toroidal differential sensing transformer that detects any current unbalance between the neutral and hot wires, and solid state components that amplify the different currents to actuate a solenoid which trips open the circuit . The device limits the time that a person might receive a shock if the current producing the shock is above the GFCI threshold trip value. The main purpose of electrical power on construction sites is to operate tools during construction. These tools almost always must be inter connected to the power receptacle with either one or more extension cords.

IV. FIELD EVALUATION OF GFCI

The electrical system is more exposed to weather conditions at the beginning of a construction project, the frequency of nuisance tripping* had often changed between the time that a site contractor had reported problems and the time the CERL field investigation was made therefore, much of the field information in this report is based on interviews with both the contractor and Corps of Engineers site personnel. The information is believed to be relatively factual.

Field data were derived from:

a) Trip threshold measurements on GFCIs
b) Observations of trips caused by operation of electrical tools
c) Observations of trips caused by operation of radio transmitters.
d) Observations of installed GFCIs which had become inoperative due to failure.

All contractor connents considered in the evaluation were obtained in the presence of COE site personnel and were not contested,

V. LABORATORY TESTING

Threshold tests were performed for two reasons (1) to ascertain the **A** test sample GFCI's trip threshold as a standard for comparing the same GFCI in adverse environmental conditions and (2) to ascertain that the GFCI tested was typical of those used on construction sites. The RF, UHF, microwave, switching noise, and field exposure tests were made because reports from construction sites indicated that these were problem areas. Vibration tests were performed because GFCIs must be used on portable generators where they are subjected to vibrations from the driving source. These tests also ascertained the effect of possible vibrations common on permanent installations, ground transmission of vibration caused by operating equipment, such as trains or trucks, and the slamming of doors close to a GFCI. Hot/cold tests were performed because a GFCI at a construction site is normally installed outside where it is subjected to temperature extremes.

VI. INSTRUMENTATION

The special requirement of measuring GFCI reaction time necessitated construction of a special threshold fault tester by CERL. The signal source normally used was a Hewlett Packard 8601A Generator/Sweeper, which can provide either CW, AM, or a swept range of frequencies from 100 kHz to 110 MHz. An Electronic Navigation Industries Model 310L RF power amplifier was used to boost the power level to 10 W. This amplifier has a pass band response of 100 kHz to 110 MHz. Thus, changing frequency required only turning the dial of the signal source. For broad-band noise testing, a General Radio Noise Generator, Model 1390A, was substituted for the 8601A as a signal source. This generator provided noise with flat spectral density from 100 kHz to 5 MHz. Noise power level attainable was 20 W. The RF field simulator used was a parallel plate transmission line with a flat center section and tapered end sections. The flat center section was 6 ft (1.8 m) long and 2 ft (0.6 m) wide. The flat plates were separated by a distance of 10 cm to enable simplified calculation of field intensity in volts per meter. The tapered sections on each end of the simulator allowed connection of source and load, while maintaining approximately the same characteristic impedance used for the flat center section. A Time Domain Reflectometer determined the characteristic impedance of the line, which was approximately 50 n.

VII. SWITCHING NOISE

The instrumentation used in the switching noise testing included the threshold and trip time measurement instrumentation described in the Trip Threshold section, the load, and the relay and relay driver. This driver can accept a signal from either a

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random noise generator or from a sine or square wave generator. The amplifier stage at the front end of the circuit squares the signal, and the flip flops with appropriate random noise input divide the frequency to a range acceptable by the relay. The relay used is Potter & Brumfield PR7DXO which has double-pole, single-throw, normally open (DPST-NO) contacts rated at 25 A. Due to the high current and heavy contacts, contact arms, and armature.

VIII. 8. VIBRATION

The following instrumentation provided the driving force and acceleration monitoring during the GFCI vibration testing.

a) Wavetek Sweep Generator, Model 147
b) MB Electronics Power Amplifier, Model 2250
c) MB Electronics Accelerometer, Model 354, Serial 119
d) MB Electronics Zero Accelerometer. Serial 1207
e) MB Electronics Vibration Exciter, Model PM5O, Serial 720.

IX. CONDENSATION

GFCIs were tested **for** susceptibility to condensation by placing them in a specially prepared chamber for 4 weeks. A vaporizer maintained the chamber's relative humidity as close to 100 percent as possible. The temperature in the chamber was maintained at approximately 90’F for the entire period. The test procedure involved applying power to the GFCIs for an operational checkout; no power was applied to the GFCIs except during actual testing. The Model GFT 200 Ground Fault Tester, manufactured by ITE Imperial was used to determine the GFCI trip current threshold for this test. The CERL threshold tester is considered the standard since its mA meter is within required calibration.

X. FUNCTIONAL DISCRIPTION OF GFCI

The functional description of a typical GFCI. As long as the current flowing in the black wire equals the current flowing in the white wire, the voltage in the secondary winding of the differential transformer is zero. If current above the trip value of the GFCI flows to ground. the solid state electronic circuitry causes the interrupter solenoid to disconnect the circuit. Energy to operate GFCIs is supplied by the building branch circuits. GFCI be capable of interrupting the electric circuit to the load when the fault current to ground is with in the range of 5 to 264 mA is accordance with following relationship.

$$T = (20/I)^{1.43}$$

where T is in seconds and I is the fault current to ground in milliamperes. a plot of this equation which can be compared with the curves showing the electrocution threshold for adults, the let-go threshold and maximum expected body currents on ordinary branch circuits. GFCI’s will not function to protect the circuit against line-to-line overloads . A fuse or circuit breaker is required for this purpose. On most branch circuits however a circuit breaker will not open until current exceeds 15 to 20 A, which of the course is far above maximum expected currents through the body.

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XI. CONCLUSION AND FUTURE SCOPE

This report describes and analyzes the use of GFCIs in buildings. The performance required of GFCIs is related to the effect of electric shock on the human body. Other means of protecting against electric shock are discussed. Protection by GFCIs against some, but not all electrically caused fire is discussed information is included concerning the history research testing foreign experience installation practice manufactures types and cost of GFCIs. Upto the Present time, only round electrical conductors have bee used In building wiring except in a fax major prototype. This report on the survey of GFCI usage assume the use of conventional electric cables with the round conductors unless otherwise stated.

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