ABB white paper

Industrial-Strength Ground-Fault Protection Safeguards Against Costly Downtime and Repairs

In 2007, lightning caused an electrical ground fault that shut down a fluid catalytic cracker at a Holly Corp. refinery in Artesia, N.M., for 10 days. In a quarterly report, the company, now part of HollyFrontier Corp., said the incident, combined with an outage at another facility, resulted in a 3 percent decrease in refinery production levels compared with the year-earlier period.

Nearly one year later, a Motiva Enterprises LLC refinery in Port Arthur, Texas, shut down after a ground fault malfunction in the internal electrical system caused a power outage at the plant. As a precaution, the company sent five workers to the hospital for heat exhaustion and other symptoms.

Ground faults are more common in industrial settings than many people may perceive. Although most electrical applications are not required by code to have ground fault equipment protection in the U.S., most short circuits are initially manifested as ground faults. These incidents can cause major disruptions in industrial environments.

Oil refineries and other asset-intensive manufacturing operations with continuous operations can't afford extended periods of downtime. That's why ground fault equipment protection (GFEP) is critical for any facility with significant capital investments. GFEP is a device that can be installed in industrial environments as a form of insurance against potentially damaging and dangerous ground faults, says Jeff Disbrow, product manager for ABB Inc. surge protection and ground fault devices. GFEPs are also referred to as residual current circuit breakers (RCCBs) in countries outside of the US and Canada. RCCBs are part of the residual current device (RCD) family

"It's a good way to determine a problem before it happens," Disbrow says. "For instance, if you have a damaged grounding connection and you don't know about it, and a leakage current of a few milliamps, a standard circuit breaker probably couldn't detect it immediately thus creating a current flow within your network that could damage some equipment or, even worse, degenerate into a fire. But if you have a bad grounding connection and ground fault protection, it senses a problem and trips the electrical circuit. That might lead you to do some additional investigation to see if you have bad wires. It's a form of proactive, preventive maintenance."

Ground faults: Why your facility may be at risk

A ground fault is caused by an insulation loss between a live conductor and an exposed conductive part that sends a flow of current to the ground. For instance, when the protective layer of a wire is broken and comes into contact with a part that isn't live, such as the equipment frame of an appliance, a ground fault can occur.

The main causes of insulation loss are breakdowns due to aging, mechanical breaking (digging into and breaking an underground line) or exposure to corrosive environments, such as chemical plants or plants located near saltwater. Industrial facilities typically most at risk include chemical plants, refineries, wastewater treatment plants, semiconductor facilities and pharmaceutical plants.

> Ground faults often generate a short circuit that can cause power losses and equipment malfunctions. Fires are also possible if the ground fault comes in contact with a flammable material.

"In semiconductor and oil and gas industries they realize any downtime is quite expensive," Disbrow explains. "Even in a semiconductor facility where the environment may not pose as much of a risk to their equipment, they want to be protected because of the investment they've made."

In some cases, electrical systems can be susceptible to ground faults in humid environments. Humidity can create a loop for the current flow even when there isn't an actual insulation fault. Humidity is a conductive element, allowing the current to flow through it.

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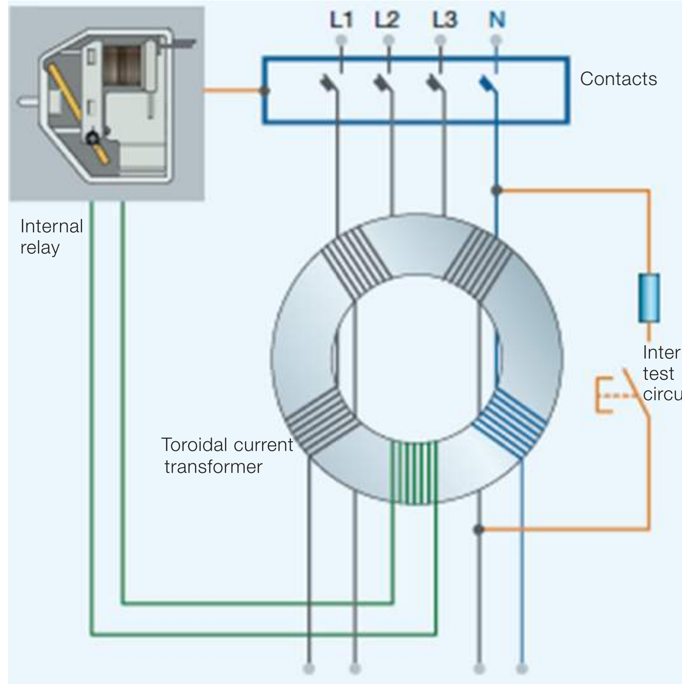
How GFEP devices can protect your investment

Fortunately, GFEP devices can shield industrial operations from the damaging effects ground faults can have on their operations. Circuit breakers are adequate for protection against a ground fault when the grounding arrangement has been made in a proper way (low resistance), the fault could be considered as a bolted fault (low resistance in the contact point) or the circuit breaker is protecting lines that are not very long.

But sometimes the grounding arrangement resistance is damaged, there isn't a bolted fault or long cables cause a high electrical impedance. In these cases, the circuit breaker doesn't trip instantaneously, or in the worst cases, it doesn't trip at all because the ground fault current is strongly limited.



GFEP internal diagram

GFEP devices can provide another level of protection not afforded by circuit breakers. They operate similarly to ground fault circuit interrupters (GFCI) that are typically found in homes. In residential applications, these are commonly visible as the "reset" and "test buttons" on electrical outlets. If a cut in the wire causes some current leakage to a grounded object, these devices will sense the imbalance and "trip" or shut down the circuit. GFCI devices typically trip when currents reach 5 milliamps (mA).

> "GFEP devices are not intended for people protection in the U.S., but by creating a safer environment for the equipment they are creating an environment that is safer for people too."
> – Jeff Disbrow, product manager, ABB, surge protection and ground fault devices

GFEP devices work in the same way but are designed to protect equipment in industrial or commercial settings. These devices typically offer protection against currents of 30 mA to 1,000 mA. U.S. electrical codes only require GFEP devices for outdoor electric deicing and snow-melting equipment (NEC 2011 - Article 426.28) and electric heat tracing and heat panels (NEC 2011 – Article 427.22).

GFEP devices measure the difference between the current flowing through the conductors. If these do not sum to zero, it means there is a leakage of current to the ground. In this case, a transformer generates an electro-magnetic flow. This magnetic flow generates a current that supplies the internal relay that will open the GFEP contacts and disconnect power to that circuit.

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How to select the right GFEP device for your application

When selecting a GFEP device, users must consider the voltage of their equipment, the amount of current being generated and tripping sensitivity. "You need to know the technical aspects of what you're trying to protect," Disbrow says. "There are a few different types of these devices that also prevent against unwanted tripping."

GFEP devices are usually classified as "AC type" for alternating fault current only, "A type" for alternating or pulsating fault current with DC components or "B type" for alternating or pulsating with DC components and continuous fault current.

- **AC type** GFEP devices are suitable for all systems where users have a sinusoidal earth current (the electrical wave shape for AC currents). They are not sensitive to impulsive leakage currents up to a peak of 250 A. These types of current leaks typically occur when voltage impulses overlap on the mains, which can be caused by the insertion of fluorescent bulbs, X-ray equipment, data processing systems and SCR controls.
- **A type** GFEP units are also not sensitive to impulsive currents up to a peak of 250 A. They are suitable for protecting equipment with electronic devices that are used for rectifying the current or phase cutting adjustment of a physical quantity, such as speed temperature or light intensity.
- **B type**, in addition to detecting fault current waveforms of the A type GFEP, are also sensitive to smooth DC ground fault currents. B type GFEP devices are recommended for use with drives and inverters that supply power to motors for applications such as pumps, lifts, textile machines and machine tools. B type devices are also recommended for uninterruptible power supplies and certain types of medical equipment, such as X-ray machines.

In addition to the UL 1053 Standard ("Ground-Fault Sensing and Relaying Equipment"), ABB GFEP devices comply with the International IEC/EN 61008/61009 product standards. These are the International Electrotechnical Commission standards for residual current circuit breakers. Also, ABB's type AC, A, AP-R devices are approved to standard UL 1053.

Climate considerations: Users should also consider a device that can be used in ambient conditions where the temperature of the surrounding atmosphere has values between -13 degrees Fahrenheit and +131 degrees Fahrenheit, Disbrow recommends. Such devices can handle extreme temperatures outside the facility, such as the desert and cold winters, as well as indoors,

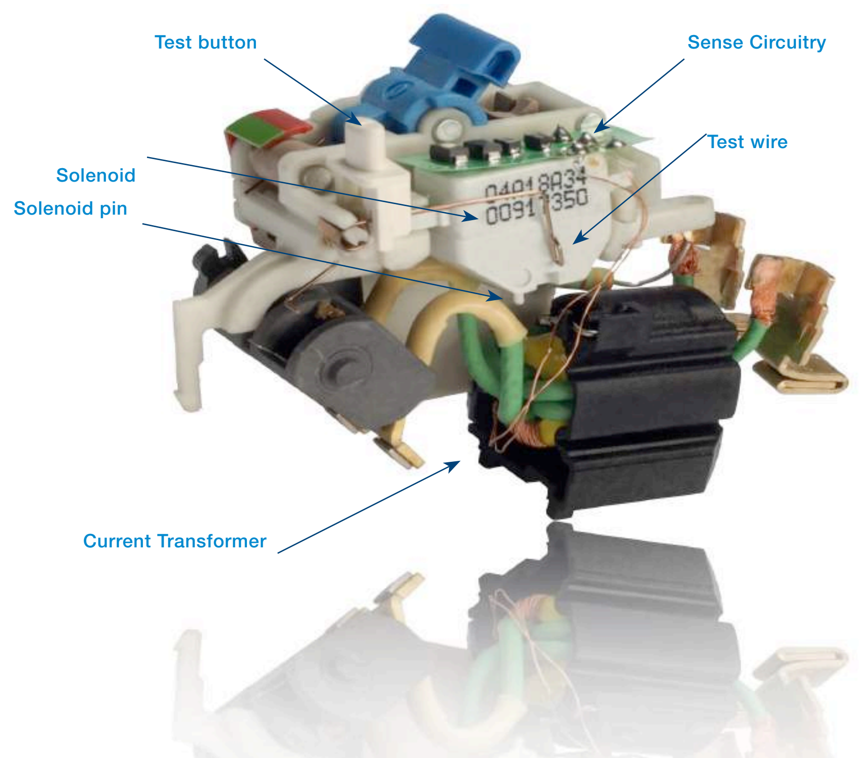
GFEP

Current Transformer:
When leakage occurs, some current takes a path to the ground, causing an imbalance in the current transformer. The imbalance is then detected by the sense circuitry.

Sense Circuitry:
The sense circuitry actuates the solenoid, causing the contacts to open by a spring.

Solenoid:
Once actuated, a plunger at the bottom of the solenoid trips the GFEP.

Test Button:
Pressed to verify correct operation of the device by passing a small current through the test wire that simulates leakage to the ground.



including furnaces in steel mills and power plants and cold rooms. They can also handle snow melting and deicing.

Selecting the proper sensitivity range for a particular application is crucial as well to prevent unwanted tripping. Lower sensitivity ranges—between 500 mA and 1,000 mA—are typically suitable for industrial complexes or large service complexes. Smaller manufacturing plants and laboratories should consider more sensitive GFEP devices that trip at ranges of 30 mA to 500 mA.

Size selection: GFEP size is another factor to consider. Users have the option of two-pole or four-pole GFEP devices depending on their electrical network. For instance, if you have a 480-volt delta three-phase network, users must buy the four-pole model because of the number of connections on their system.

In addition, some GFEP devices require an external power source to open the device's contacts, which will then disconnect the power to the circuit during a ground fault. But ABB's GFEP devices use a toroidal current transformer that, in case of fault, generates a current used by an internal relay to open the GFEP contacts. With this feature, there is no need for an external power supply because the internal relay uses limited energy by the toroidal transformer to open the contacts.

Prevent unwanted tripping with AP-R GFEP devices

Even with careful consideration of GFEP options, unwanted tripping can still occur. Typical reasons for these disturbances usually include:

- Operation overvoltages caused by inserting or removing loads (opening or closing protection of control devices, starting and stopping motors, switching fluorescent lighting systems on and off, etc.)
- Overvoltages of atmospheric origin caused by direct or indirect discharges on the electrical line

Under these circumstances breaker tripping is unwanted because the GFEP is not responding to risks due to direct and indirect contacts. In addition, the sudden and unnecessary interruption of the power supply can cause serious problems, such as losses in production. ABB provides a range of anti-disturbance GFEP that were designed to overcome the problem of unwanted tripping caused by overvoltages or atmospheric or operation origin.

The electronic circuit in these devices can distinguish between temporary leakage caused by disturbances on the mains and permanent leakage caused by actual faults. ABB's AP-R range of GFEP have a slight tripping delay, but this does not compromise the safety limits of the device. The device's installation in the electric circuit prevents unwanted tripping in industrial systems in which continuous service is essential. The delayed trip makes the AP-R device suitable for:

- **Installations involving motor starters/variable speed drives, fluorescent lamps or IT/electronic equipment.**
- **IT system loads and other electronic equipment, such as dimmers, computers and inverters with capacitive input filters connected between the phases and the ground.** These filters can generate permanent earth leakage currents that may provoke nuisance tripping of a standard GFEP. AP-R breakers allow a greater number of devices to be connected to the installation.
- **Faults within a single-phase frequency converter.** In these instances, AP-R type GFEP devices provide complete protection because an earth fault occurring downstream from the inverter produces an earth-fault current with multi-frequency shape with a high amount of harmonics. In the event of a fault within a three-phase frequency converter, B type GFEP devices are suitable. Overall, AP-R GFEP provide a tripping time delay and better resistance to overvoltages, harmonics and impulse disturbances than standard type GFEP.

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Conclusion

As demonstrated by recent plant shutdowns, ground faults can result in accidents that can cripple production, disrupt supply chains and damage expensive equipment. Equipment that is exposed to corrosive environments is particularly susceptible to ground faults. GFEP devices provide a layer of protection beyond standard technology, such as circuit breakers. They may also improve workplace safety.

"GFEP devices are not intended for people protection in the U.S., but by creating a safer environment for the equipment they are creating an environment that is safer for people too," Disbrow says.

While some industrial operations may hesitate to install GFEP devices because of false tripping or cost, power technologies manufacturers, such as ABB, offer a wide range of options to reduce or eliminate these potential headaches. This includes products with varying sensitivity ranges and GFEP devices with their own power source.

Once industrial customers select the GFEP device that is appropriate for their respective application, they can apply additional protections to further safeguard equipment against ground faults. This includes regular inspections of wiring in the panels and other accessible areas. They can also install surge-protection devices to protect against overvoltage. Taking these steps along with the installation of GFEP devices can eliminate costly disruptions to operations and potential hazards.

To get in touch with your local expert, please go to: http://lvpinfo.com/211 or contact:

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