

Underground mining systems— the invisible and looming danger



Introduction

If people aren't in harm's way, they can't get hurt. Seems reasonable, right? Of course, this is the reason that many mines are trending toward automation and remote monitoring of electrical systems. It's also the reason that electrical workplace safety standards, such as NFPA® 70E of the National Fire Protection Agency, and CSA Z462 of the Canadian Standards Association, are focused on moving workers away from dangerous arc flash hazards. But in the midst of many technology advancements designed to protect and save lives, there is one looming and invisible danger that seems to have gone unnoticed. The danger comes in the form of a colorless, odorless gas that is heavier than air, excludes oxygen, and is toxic in decomposition. Unbelievably, this gas is often applied in many electrical systems in underground mining—this gas is sulfur hexafluoride, more commonly known as SF₆.

Why is SF₆ used?

Sulfur hexafluoride offers excellent insulating or dielectric properties and, as such, the gas has historically been applied in medium voltage and high voltage electrical distribution equipment. Included here is SF₆ Gas Insulated Switchgear (GIS), where assembly busbars are enclosed in a sealed chamber with the gas serving as an insulator between conductor phases, effectively replacing air. SF₆ switchgear falls under three categories: closed pressure systems, controlled pressure systems, and hermetically sealed systems. Among these, hermetically sealed systems do not require maintenance, and manufacturers claim that SF₆ leaks are very limited during the equipment's lifetime. However, with all three systems, SF₆ is emitted into the atmosphere during various phases of the product's life cycle.

SF₆ is also used as an interrupting medium in circuit breakers applied in switchgear assemblies. The gas, which is sealed in a cylindrical container, quickly and efficiently extinguishes the electrical arc established when the breaker contacts are opening or interrupting a fault. Although switchgear and circuit breakers that use SF₆ are designed to be sealed systems from which the gas has no opportunity to escape, all SF₆ systems include monitoring devices designed to detect and alarm an accidental release of the gas into the environment.

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SF₆ leaks can be catastrophic

When subjected to electrical discharges, SF₆ forms highly toxic and corrosive compounds. Some of the prominent byproducts and their toxicity levels include:

- Sulfur tetrafluoride (SF₄) >>> Highly toxic
- Sulfur pentafluoride (SF₅) >>> Toxic, but nonhazardous
- Sulfur dioxide (SO₂) >>> Highly toxic
- Hydrofluoric acid (HF) >>> Hazardous and toxic

Beginning in 2002, the U.S. Environmental Protection Agency (EPA) established a voluntary program in which partner companies agreed to reduce SF₆ emissions through technically and economically feasible actions. The EPA program report states: "SF₆ is a potent and persistent greenhouse gas, with a global warming potential approximately 24,000 times greater than carbon dioxide over a 100-year time horizon and a residency in the atmosphere of more than 3,000 years." Because of these known dangers, electric utilities across the globe that use equipment containing SF₆ gas have been forced to adhere to strict environmental procedures controlling its use. Some of these include:

- Tracking and recording maintenance activities of all equipment that uses SF₆ gas
- Minimizing on-site storage of SF₆ used to support maintenance of existing equipment
- Assuring that a robust program is in place to remove and destroy all SF₆ prior to decommissioning at the end of equipment life
- Identify and repair leaks from operating equipment immediately upon detection
- Have a written and approved hazardous material handling/cleanup process in the event of an SF₆ leak
- Minimize the release of SF₆ gas into the atmosphere

What are mining regulatory authorities saying about SF₆? In North America, it appears that although some government regulating bodies do publish safe work practice documents around SF₆, none are prohibiting or restricting its use. This includes application of power centers in underground mining electrical systems, where a possible SF₆ leak in a low-ventilation environment could have catastrophic consequences.

The answer: vacuum technology

Air-insulated vacuum switchgear is "SF₆ free," eliminating the risks of emissions during manufacturing, installation, maintenance, and decommissioning of SF₆, or leaks during its service life. The image below shows one of the newer designs in vacuum circuit breakers, where instead of interrupting an electrical arc in SF₆ gas, the arc is instead interrupted in a sealed vacuum bottle. Vacuum technology, which has been commercially available for over 50 years, effectively replaces the use of SF₆ and assures enhanced safety for electrical systems in underground mining applications. The vacuum circuit breaker shown is available in a host of ratings from 2.4 kV through 24 kV, and 630A through 2000A, and with interrupting ratings through 50 kAIC. The new breaker designs include an epoxy housing that fully protects the vacuum interrupter from harsh environments and a robust mechanism that is tested for 20,000 mechanical operations. The new designs offer a smaller footprint and a lower first cost than many of the comparable SF₆ circuit breakers. (To learn more about vacuum circuit breakers designed for underground mining, [click here](#).)

With new extended vacuum circuit breaker ratings, there is simply no practicable reason that SF₆ circuit breakers would ever be applied in underground mining systems. Mining regulatory authorities should carefully consider banning electrical systems that employ SF₆ gas based on the overwhelming dangers cited here and in numerous studies. Some mining authorities are now requiring assembly type-testing of underground power centers, including short-circuit and heat-rise tests. These efforts to enhance equipment safety should be coupled with requirements to also exclude the use of SF₆ circuit breakers to enhance people safety. Mitigating risk to miners by requiring vacuum technology for all medium-voltage circuit breakers in the mining industry is a much needed future regulation, necessary for improvements in electrical workplace safety.



New Eaton W-VACi-MB medium voltage vacuum circuit breaker is SF₆ free.

Eaton Corporation
Electrical Sector
1111 Superior Avenue
Cleveland, OH 44114 USA
Eaton.com

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