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SPECIAL EDITION

The Three R's:
Reducing the Environmental Impact of SF_6

ABSTRACT:

Sulfur Hexafluoride (SF_6) Gas is used as an electrical insulator and arc suppressant in high and medium voltage electrical equipment in the electrical power utility and industrial power industries. SF_6 is also used in medical devices, metal production and other manufacturing applications. The same properties that make SF_6 useful as a dielectric create environmental problems. SF_6 is a major greenhouse gas with a GWP of 23,900; however, with proper training and equipment, SF_6 can be used in a closed loop cycle where it is not emitted into the atmosphere. Utilizing the three Rs: Recover, Recycle, and Re-use, along with best gas handling practices the T&D industry can enjoy the benefits that SF_6 provides while minimizing environmental impacts.

HISTORY:

Discovered in 1901 by French Chemists Henri Moissan and Paul Lebeau, Sulfur Hexafluoride is a man-made gas that has a greater dielectric strength and density than air. When in pure form, SF_6 is inert, non-flammable, non-toxic, thermally stable, and has unmatched arc quenching capabilities. Most interesting is the molecule's self-healing abilities. The gas begins to break down at a temperature of 380 degrees Fahrenheit and once the heat source is removed, the atoms will regenerate like new. The chemical properties of SF_6 make it ideal for use within circuit breakers and switchgear.

ENVIRONMENTAL IMPACT:

Unfortunately, the same properties that make SF_6 such a great insulating gas also make SF_6 the most potent of all greenhouse gases. One molecule of SF_6 can trap 23,900 times more heat than carbon dioxide over a 100-year period and remains in the atmosphere for thousands of years. About 80% of manufactured SF_6 is used in high voltage equipment like switchgear and circuit breakers (GIE).

When SF_6 gas performs its job correctly under normal conditions, the gas absorbs the energy of an arc by creating resistance across the gap. Once the arc is quenched, and the high temperature removed, SF_6 gas recombines. In a perfect world, the same amount SF_6 initially added to gas insulated equipment (GIE) could be used indefinitely. In reality, the creation of gas by-products, gas handling mistakes, GIE leaks and the introduction of contaminants reduces the effectiveness of SF_6 gas as an insulator and arc quencher in GIE. Additionally, emissions of SF_6 during gas handling contribute to climate change. Despite its potential environmental impact, SF_6 is an excellent electrical insulation and arc quenching gas in GIE with unmatched dielectric strength. Users can enjoy the benefits of this medium while greatly reducing environmental impact by following the Three Rs: Recover, Recycle, and Re-use.

Self sealing fittings reduces gas handling emissions

Gas recovery equipment designed for emission free gas handling

THE THREE R'S:

Recover: This requires capturing the gas from a GIE through an emission free process that includes filtration of contaminants such as moisture, SF_6 gas by-products and sometimes, oil. When completing SF_6 recovery using a gas cart, it is imperative to reach the lowest level of vacuum possible, or "blank-off pressure." Generally, reducing the amount of gas in a breaker to atmospheric pressure alone leaves a startling 20% of residual gas within the GIE. Starting additional maintenance while residual gas is still present can cause an emission.

Recycle: Major contaminants such as, moisture, decomposition products, other vapors, and oil can be found in used SF_6 gas; however, the contaminants can be removed by filtration and separation to improve quality and recycle the gas. There are generally four filter types which apply to SF_6 gas filtration:

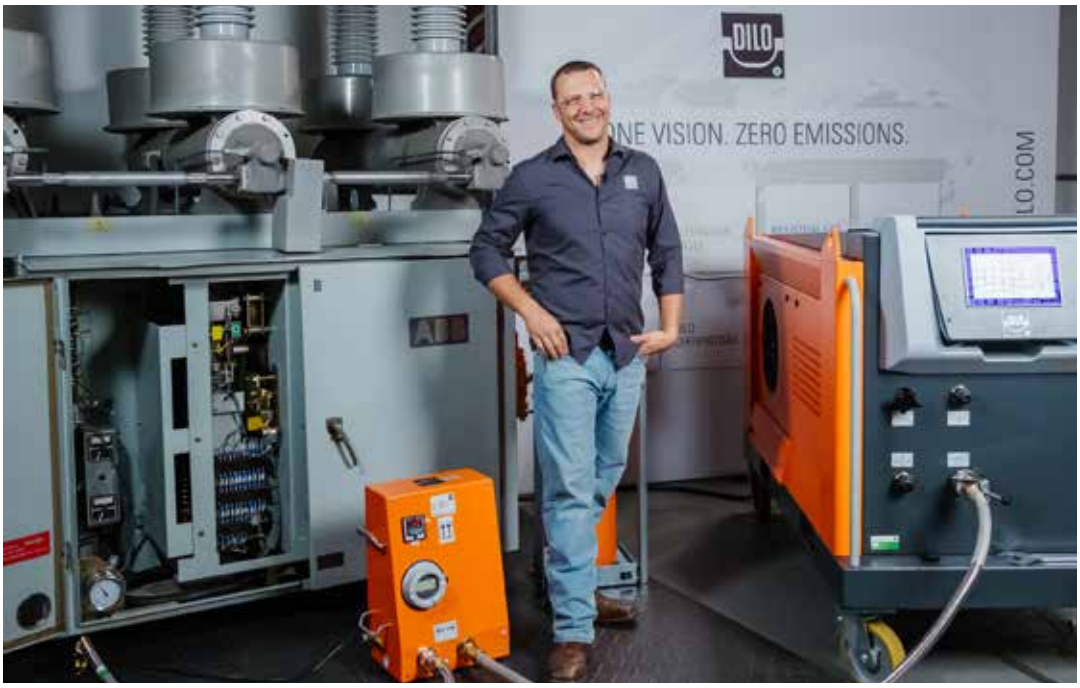
1. ***Activated Charcoal*** *has a high surface area, high bulk density and particle size distribution, activated carbon is used for the removal of organic compounds such as oil from SF_6 gas. T*
2. ***Aluminum Oxide*** *(AL_2O_3) separates moisture and by-product from the vapor by acting as an absorbent attracting those compounds.*
3. ***Molecular Sieve Desiccant*** *removes and traps water molecules within them to achieve separation from SF_6*
4. ***Particle filters*** *are designed to trap solid particles that may include solid decomposition material from SF_6 gas by-products and other solids which may cause damage to recovery system and accessories, and GIE. Particle filters are generally designed to maintain a 100% capture rate of particles that are ≥1.0µm.*

Re-use: The processing of the gas through an emission free and filtration sub-system to remove contamination allows the gas to be reused in GIE immediately or introduced into the supply stream for future reuse without the need to purchase new or virgin SF_6 gas. It is reported that the emission rate of the production of new/virgin SF_6 gas is around 30lbs to 80lbs for every 100lbs of SF_6 gas produced. SF_6 gas is 100% recyclable. When SF6 gas is recycled, the emission rate is only ≤0.64lbs for every 100lbs recycled. In the same token, for every 100lbs of gas reconditioned the emissions are only ≤0.5lbs.

SF_6 GAS RECONDITIONING

In some cases, SF_6 gas may need to be reconditioned to remove vapors prior to being re-introduced to the supply stream. Reconditioning is a process that occurs after the Three R's used to separate SF_6 gas from other vapors (i.e., N_2, O_2, CF_4). In short, reconditioning is a cryogenic process that is combined with filtration and high pressure through an emission free process.

There are limited suppliers in North America that can recondition SF_6 gas which must meet the requirements and ensuring zero emissions. The end goal is to meet the standards set by CIGRE, IEEE, ASTME and IEC. When the process is followed correctly the standards can easily be exceeded.



Gas handling equipment operated by trained professionals ensures zero emissions

SUMMARY

SF_6 continues to be the best insulating medium for high voltage electrical insulation and arc quenching gas in GIE. Turning to the existing stockpile of SF_6 gas offers an environmentally friendly alternative solution to importing virgin SF_6 gas from overseas. The implementation of reconditioned SF_6, which has been properly treated to meet or surpass IEEE/CIGRE standards, helps to reduce the carbon footprint and eliminates SF_6 emissions that are the direct result of the manufacturing process. Utilizing the Three Rs: Recover, Recycle, and Re-use, the T&D industry can enjoy the benefits that SF_6 provides while minimizing environmental impacts.

EMISSION FREE GAS HANDLING TECHNIQUES

In addition to using the Three R's, field training is essential to safeguarding your organization from unintentionally leaking SF_6 into the atmosphere. Properly trained technicians that utilize best practices for SF_6 gas handling are the first line of defense against emissions. Below are some basic methods on preventing emissions during the circuit breaker maintenance process.

1. **Filling –** Be sure to check the OEM's manual or nameplate for accurate SF_6 capacity information. Accidently overfilling GIE could result in an SF_6 emission by engaging a pressure relief valve. Tracking gas weights by documenting SF_6 movements and using a cylinder weight scale can aid with preventing both positive and negative emissions.
2. **Testing** - SF_6 analysis to determine gas quality prior to performing maintenance is a standard practice. Toxic SF_6 by-products can cause damage to GIE and gas handling equipment and be extremely harmful to human health. It is important to use a collection bag when taking gas samples if your test equipment is not equipped with a self-recovery feature.
3. **Fittings & adapters** – Check to see that fittings used for connection to GIE and other accessories (manifolds, analyzers, cylinders, etc.) are leak tested. Refrain from using threaded connections, which are prone to leak over time.

Billy J Lao is the General Manager and CEO of DILO Company Inc. and DILO Direct. DILO specializes in SF_6 gas and SF_6 Gas Alternatives handling equipment, services, and gas supply for North America.

Billy Started as a Field Service Technician for GEC ALSTHOM (now GE Grid T&D) in 1992. He later was appointed Director of Services for ALSTOM T&D (aka AREVA T&D). Billy went on to work for SIEMENS as a Regional Service Manager and eventually director of Services for USA before moving to DILO.

Billy is a member of and a Working Group Chair for IEEE committees for the SF_6 Gas Handling Guide and the SF_6 Gas Alternatives Handling guide. In addition, he is a member of the SF_6 Gas and Alternatives Coalition and recently has become a member of the ASTM D27 committee.

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