SF_6 and a world first

ABB launches the first-ever SF_6 recycling center

BRETT ALEXANDER, DUNCAN ROBBIE, MARCUS MARENGHI, MICHELLE KIENER – ABB has developed a patented technology for the comprehensive recycling of contaminated sulfur hexafluoride (SF_6) gas, based on a new energy-efficient cryogenic process. The new technology will be implemented at a dedicated SF_6 gas recycling center, which ABB has recently established in Sydney, Australia. The purity of recycled SF_6 gas using the newly developed technology is about 99.99 percent and is in accordance with technical grade IEC 60376 (the standard for new gas), which enables SF_6 to be reused again and again. Using recycled SF_6 gas will help reduce carbon emissions and could result in a cost savings potential of up to 30 percent.

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Sulfur hexafluoride is an inert gas used extensively in the electrical industry for dielectric insulation and current interruption in circuit breakers, switchgear and other electrical equipment. An advantage of SF_6 is that it allows the transmission of higher power levels in a smaller footprint compared with other insulating mediums. Such advantages are particularly important for electricity transmission in city substations or offshore wind applications. SF_6 filled devices have continually decreased in size and increased in capacity over time. Pressurized SF_6 gas is used for the safe and reliable operation of gas-insulated switchgear (GIS) as it has a much higher dielectric strength than air or dry nitrogen, making it possible to significantly reduce the physical footprint of the equipment and enable installation in constrained spaces. GIS also has the advantage of being more resistant to hostile operating environments, which results in better long-term operating reliability.

Despite the advantages that SF_6 brings, its use is not without its challenges. The cost of handling SF_6 in a compliant manner can also be substantial, particularly when decommissioning aging substations. According to the Intergovernmental Panel on Climate Change, SF_6 is the most potent greenhouse gas that it has evaluated, with a global warming potential of 22,800 [1] times that of CO_2 when compared over a 100-year period. In Europe, the use of SF_6 has been heavily regulated since January 2008, for all applications including switchgear [2]. So while using this gas does present challenges, it remains an extremely beneficial, useful and valuable commodity, which should be conserved where possible. This means that the life-cycle management of the gas can be a significant challenge for utility and industrial users.

Development of the new SF_6 recycling plant

Driven by environmental considerations, and the goal of providing total solutions for its customers, ABB has, for many years, been researching ways of recycling used SF_6 from electrical switchgear and circuit breakers. Initially a manual cryogenic process for purifying SF_6 had been identified that had several limitations. These were primarily poorly reproducible product quality and safety con-

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Title picture
SF_6 recycling center, Sydney, Australia

1 Full scale prototype SF_6 recycling plant

cerns regarding exposure of operators to liquid nitrogen.

As a result, a new research and development project was initiated to develop a safer, better controlled and largely automated process. The outcome of this project was the first fully automated cryogenic SF_6 purification plant in the world. The entire project represents an innovation in itself; some of the individual innovations are:

– A novel gas separation chamber to freeze SF_6 under cryogenic conditions
– A rigorous automated process control system that balances inventory and prevents leakage

Rigorous iterative engineering design techniques were used to develop these innovations. The first step involved process selection with pros and cons and suitability with respect to the design constraints. This resulted in a new process that involves a cryogenic step to remove noncondensable gases, chiefly nitrogen, from the used gas, and a filtration process to remove contaminants including water, various acids, toxic by-products and oil.

Detailed process design resulted in the validation of the design using arithmetic models, and information from suppliers ensured the feasibility of mechanical fabrication. This is where the process really became iterative as the implications of equipment selection on other parts of the plant became evident. Being almost entirely novel, the vessels for cryogenic separation required significant interaction with the manufacturer because reference designs or examples did not exist. During the detailed design, the logical process steps formed the basis of the automated PLC program and process control scheme.

Two hazard and operability studies expanded the operational knowledge of the process to the wider team and improved plant operability.

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Commissioning of the plant focused on the piping, electrical, software and control systems. As many of the methods being used to control both the process and the pressure vessels for the cryogenic separation were being developed for the first time, a conservative approach to commissioning was used. This involved testing the individual processes, first with nitrogen, and then with carbon dioxide before final extensive testing using SF_6 went ahead. These tests allowed the process parameter models to be refined, and also proved that the technology is capable of separating out contaminants from SF_6.

The final result was engineered and constructed as a full-scale prototype plant, capable of recycling SF_6 at all contamination levels and bringing SF_6 up to new technical-grade quality. ➔ 1–2.

Successful outcomes

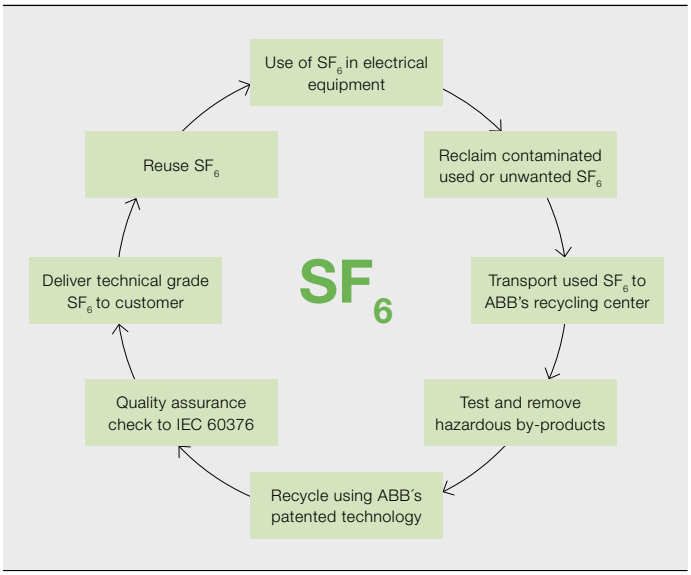
Launching the SF_6 gas management business on the basis of the newly developed SF_6 recycling technology has provided successful outcomes in technical, commercial, safety and environmental areas.

The greatest technical advantage of the new process in comparison with existing technology is that it can efficiently recycle SF_6 irrespective of the type or level of contamination. Existing technologies suffer from an inability to treat all contaminants and all contamination levels in one process. Furthermore, the level of automation present in the new process allows significantly greater throughput and energy efficiency.

While SF_6 is relied upon for its insulating and arc-quenching capabilities, over time the gas can deteriorate, particularly if the equipment has experienced regular switching. Inferior gas quality can diminish the above mentioned capabilities, which compromises the performance and safety of the equipment. Checking the quality of the gas in equipment, as

2 SF_6 gas recycled by ABB meets technical grade IEC 60376.

3 ABB proposed SF_6 life cycle



part of a preventative maintenance program, can extend the product life.

ABB's fully qualified and accredited technicians are equipped to safely analyze and manage existing gas inventory, and to complete inspections and tests on gas quality and quantity. The gas quality inspections ensure the purity of gas in equipment exceeds the minimum standards required for safe operation. As a leading manufacturer of gas-insulated equipment and with its focus on safety, ABB has gained extensive experience in the safe handling of this gas.

The new recycling center offers a solution to a problem that previously had no commercially or environmentally friendly solution.

It can sometimes be the case that some customers hold unwanted, nonconforming or contaminated SF_6 that is no longer required due to the cost, or lack, of removal options. As part of ABB's commitment to helping customers reduce their environmental impact, the recycling center will accept any quantity or quality of SF_6 for purifying and restoration to a technical grade standard using ABB's new patented recycling process and technology.

The process is designed so that no loss of SF_6 occurs at any stage of operation. Specialist detection instrumentation in combination with an automated process control system is used to detect and prevent leakage that may result through either operator or plant fault.

To ensure safety, all plant processes have been internalized to prevent human exposure and eliminate the chance of accidental exposure to liquid nitrogen. Removal of other nongaseous contaminants is done with solid-state absorbents that are contained within high-pressure demountable housings through which the SF_6 passes. The solid waste products, now safely concentrated and contained, can be disposed of without human contact or environmental exposure. Finally, the recycling plant is operated almost entirely automatically in order reduce the risk of operator error and to maximize safety.

ABB's complete solution assists companies in reducing their environmental impact and lowers the costs associated with administration and inventory management of SF_6. The new service offering will see contaminated SF_6 gas recycled into technical grade standard (according to IEC 60376) for reuse. This allows the product life cycle of SF_6 to be closed and removes the need for energy-intensive incineration and also provides a viable route for utilities to decrease their stored stockpiles of contaminated SF_6 → 3.

The technical, safety, commercial and environmental advantages that this new recycling technology brings are clear. The new recycling center offers a solution to a problem that previously had no commercially or environmentally friendly solution. This new technology and the new plant further advance the benefits of GIS by completing total product life cycle considerations, while not altering the existing benefits of safety and reliability of this essential equipment. GIS customers can now benefit from not just a reduced physical footprint, but from a reduced environmental footprint as well.

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References

[1] Intergovernmental Panel on Climate Change, Working Group 1, Climate Change 2007, Chapter 2.10.2.
[2] Climate: MEPs give F-gas bill a "green boost." Retrieved February 15, 2012 from http://www.euractiv.com/sustainability/climate-meps-give-gas-bill-green-boost/article-145749