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EPA's SF_6 EMISSION REDUCTION PARTNERSHIP: MAXIMIZING THE BENEFITS OF SF_6 EMISSION REDUCTIONS FOR ELECTRIC UTILITIES

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1. INTRODUCTION

First manufactured in 1902, sulfur hexafluoride (SF_6) is a fluorinated compound with an extremely stable molecular structure. This structure makes it far superior to oil or air in its insulation properties, dielectric strength, and arc quenching abilities. Electric equipment manufacturers and utilities therefore rely heavily on SF_6 in transmission systems. In 2001, electric utilities and electrical equipment manufacturers (OEMs), taken together, purchased over 80 percent of all SF_6 produced worldwide (1). Under ideal conditions, SF_6 would remain contained within transmission equipment. In reality, however, SF_6 is inadvertently emitted into the atmosphere as leaks develop during various stages of the equipment's lifecycle. SF_6 can also be accidentally released during equipment installation, servicing, or de-commissioning.

SF_6 has been identified by the Intergovernmental Panel on Climate Change (IPCC) as a highly potent greenhouse gas that contributes to climate change. According to the IPCC (2), SF_6 is 22,200 times more effective at trapping infrared radiation than an equivalent amount of carbon dioxide (CO_2) over a 100-year period. Additionally, it has an atmospheric life of 3,200 years; its accumulation in the atmosphere is virtually irreversible. Measurements taken from 1978 through 1996 indicate SF_6 concentrations are increasing in the atmosphere at a rate of 7 percent per year (3). In 2002, SF_6 emissions from the U.S. electric power industry totaled 589 metric tons. From a greenhouse gas

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perspective, that equates to 14.1 million metric tons of CO_2, or 5 percent of total CO_2 and non-CO_2 greenhouse emissions from U.S. industrial processes (4). Although SF_6 is emitted in smaller quantities than other greenhouse gases, it has a significant long-term impact on global climate change. Consequently, the need to minimize SF_6 releases and avoid its accumulation in the atmosphere is important.

2. SF_6 EMISSIONS REDUCTION PARTNERSHIP FOR ELECTRIC POWER SYSTEMS – SF_6 Emission Reduction Activities

The U.S. Environmental Protection Agency (EPA) launched the SF_6 Emission Reduction Partnership with the electric power industry in 1999. Currently, more than 70 companies – representing all segments of the U.S. electric utility industry, have voluntarily committed to identify, implement, and report the results of their emission reduction activities. The Partnership provides a forum for the industry and EPA to share information of ways to reduce SF_6 emissions to technically and economically feasible levels.

The efficiency of SF_6 management can be improved through cost-effective operational improvements and equipment upgrades. These opportunities fall into four categories: SF_6 inventory tracking systems, SF_6 recycling, improved leak detection technology, and SF_6 management training programs to improve operation and maintenance practices.

2.1 SF_6 Inventory Tracking Systems

Each year, SF_6 Partners prepare and submit reports to EPA that detail their annual SF_6 emissions and emission reduction achievements. SF_6 emissions estimates are prepared using a mass-balance approach to systematically track and account for all company uses of SF_6 during the reporting year. SF_6 use accounted for in this approach includes: cylinders and equipment purchased during the reporting year, SF_6 sent off-site to destruction facilities or for recycling, SF_6 returned to suppliers, and SF_6 sold to other entities. Using this method, estimates are developed based on the assumption that any SF_6 gas that cannot be accounted for is emitted into the atmosphere.

SF_6 Partners are asked to use a standard protocol to weigh, leak check and inventory their SF_6 gas cylinders. This process enables companies to track gas purchases and the rate of gas use, thereby, ensuring SF_6 inventories are not overstocked. Since SF_6 cylinders are typically rented in the U.S., this approach also enables a utility to reduce their annual cylinder rental fee charge. Another important aspect of inventory tracking involves verification of the remaining gas or "heel" in returned cylinders. The term "heel" is used to describe the amount of gas that normally remains in the cylinder after use. It can account for as much

as 10 percent of the original cylinder gas mass (e.g., for a standard 52 kilograms (kg) SF_6 cylinder, the remaining unused gas could be roughly 5 kg). In the past, utilities typically returned cylinders to the vendor without accounting for the heel; consequently, paying for the full reported mass of the cylinder. By weighing cylinders before return, many SF_6 Partner utilities have been able to receive credit for the remaining portion of gas. The SF_6 inventory tracking system also facilitates identification of specific SF_6-containing equipment requiring frequent refilling. Since increased SF_6 consumption (loss) may indicate mechanical or structural problems, leading to potential equipment failure, SF_6 Partners have used their tracking systems to schedule maintenance and equipment replacement activities before problems occur, thus saving money and reducing unplanned system disruptions.

2.2 SF_6 Recycling

In the past during equipment servicing or replacement activities, SF_6 gas was typically vented to atmosphere. Now, however, most companies use SF_6 gas recycling carts to remove, store, clean, and re-fill the SF_6 gas to the gas-insulated equipment. Most recycling systems provide automatic gas purification/cleansing during removal and re-filling operations. Thus, recycling their SF_6 gas has enabled Partners to reduce their SF_6 gas purchase requirements. Additionally, many gas carts enable the equipment gas compartment to be flushed and evacuated before re-filling to ensure the removal of moisture, which reduces the likelihood of corrosion and thus increases electrical equipment lifetime.

2.3 Improved Leak Detection Technology

Utilities traditionally relied on soap and water solutions or "gas sniffers" to locate SF_6 leaks. This process involves de-energizing the equipment, to enable the leak inspector to get close to the equipment in order to either spray liquid soap on it, or use gas "sniffer" detection devices to detect the presence of SF_6. Both techniques are labor intensive, often requiring extensive climbing and reaching by workers, which is time-consuming, costly, and potentially hazardous. New laser leak detection systems exploit the strong infrared absorption characteristics of SF_6. Not only do these systems enable the operator to identify leaks as small as 1 kilogram per year at distances greater than 30 meters in "real-time" (6), but they provide the ability to conduct inspection on "live" equipment. Consequently, Partners are detecting minor leaks without taking equipment out of service or incurring large downtime costs, and benefit from a significant reduction in the time required to detect leaks.

2.4 SF_6 Management Training Programs

Critical to any successful emission reduction strategy is training to improve employee SF_6 handling. Effective safety and maintenance procedures, leak detection procedures, gas cart operation, gas quality testing, and arc by-product detection are all dependent on worker expertise and diligence. By implementing additional training sessions that enhance employee understanding of SF_6 gas issues, Partners have increased employee efficiency in monitoring SF_6 loss. They have also become proactive in using monitoring data to prioritize and schedule equipment maintenance and replacement.

3. PARTNER ACCOMPLISHMENTS

Since the SF_6 Emissions Reduction Partnership's inception in 1999 through 2002, cumulative reductions of nearly 132,000 kg of SF_6 (or over 3 million metric tonnes of carbon dioxide equivalent ($MMTCO_2e$)) have been achieved. This translates into an overall 11 percent reduction of SF_6 emissions from 1999-baseline levels. Table 1 provides a summary of U.S. industry SF_6 emission reductions between 1999 and 2002. Additionally, during this timeframe, the average Partnership SF_6 emission rate (or loss rate), which is defined as the total Partnership emissions divided by the total nameplate capacity of SF_6-containing equipment held by Partners, has decreased from 17 percent in 1999 to 11 percent in 2002. This accomplishment illustrates the increasing efficiency of Partner operations through the reduction in the quantity of SF_6 gas lost from equipment leakage or gas lost (or vented) during general cylinder handling and equipment maintenance activities.

Table 1. Summary of SF_6 emissions reductions achieved by Partners between 1999 and 2002.

Reporting Year	1999[a]	2000	2001	2002
SF_6 Nameplate Capacity (lbs. – millions)	3.4	3.8	3.9	4.0
Total SF6 Emissions (lbs. - thousands)	590	580	550	480
Total SF_6 Emissions ($MMTCO_2e$)	15.77	15.18	14.90	14.08
Emission Reduction from Baseline	—	4%	6%	11%

[a]Baseline Year

With the cost of SF_6 ranging from US$13 to US$18 per kilogram, SF_6 emissions reductions through 2002 equate to a financial benefit ranging between US$1.8 to US$2.4 million dollars (approximately €1.4 to €1.9 million). The environmental benefit of this reduction is equivalent to eliminating the emissions from over 590,000 cars or planting more than 10 million trees. (7)

3.1 One US Utilities' Success Story

The following information was offered by one of EPA's SF_6 Partners. This company has a service territory of 70,000 square miles and operates transmission equipment bearing over 200,000 pounds (nameplate capacity) of SF_6. This utility's effort to reduce SF_6 emissions resulted in discovering that significantly more equipment was leaking than previously thought. The use of advanced leak detection technology paid for itself though the cost savings gained from reduced leaks. This company implemented policies and procedures that initially cost $100,000 but resulted in savings in avoided gas purchases of $400,000; yielding a net savings of $300,000 (€237,300). The company now also recycles 90% of its SF_6 gas from decommissioned equipment.

Using a 1998 emissions baseline, this company reported a 50 percent reduction in annual SF_6 emissions in 2002. This success is based on a two-pronged approach aimed at enhancing both the company's SF_6 management system and facility-level maintenance procedures. The company developed a new SF_6 handling protocol and implemented training programs to educate employees on better leak detection practices, and SF_6 handling procedures, such as those required when evacuating SF_6 from circuit breakers, or transferring SF_6 from cylinders. This training has helped staff identify significant leaks on equipment, which was previously considered gas-tight.

With respect to the company's SF_6 management system, new measures were implemented to control purchases of SF_6 by improving inventory control and by reducing cylinder rental charges for late cylinder returns. The SF_6 tracking system has also provided a means to track equipment re-filling operations and coordinate leak detection activities more efficiently.

4. CONCLUSION

SF_6 is the most potent greenhouse gas known. The electric power industry is the largest user and emitter of this gas. Emissions will continue to be scrutinized as greenhouse gas mitigation options are explored. While there is currently no "silver bullet" replacement for this chemical, information from the SF_6 Emission Reduction Partnership shows that companies can achieve significant SF_6 emission reductions now, using cost-effective technologies and practices that provide additional financial benefits.

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