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Reclaiming Sulfur Hexafluoride--a System to Repurify, Store, and Recirculate SF₆

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George E. Staller, Marlin F. Aker, Jr.

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RECLAIMING SULFUR HEXAFLUORIDE--A SYSTEM
TO REPURIFY, STORE, AND RECIRCULATE SF₆

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ABSTRACT

Large quantities of sulfur hexafluoride (SF₆) gas are used in the operation of electron beam accelerators in Sandia Laboratories Technical Area V. A commercial SF₆ gas transfer cart has been modified to reclaim this gas by repurification and storage for later use. The system will not be installed and in operation until about March 1978, but it is anticipated it will be much more economical than current and estimated future costs for purchasing replacement SF₆.

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RECLAIMING SULFUR HEXAFLUORIDE--A SYSTEM TO REPURIFY, STORE, AND RECIRCULATE SF₆

Introduction

Sulfur hexafluoride (SF₆) is used as a dielectric gas in various high-voltage switching applications at Sandia.¹ Components using SF₆ are increasing in number and size.² The gas is expensive, and it is frequently necessary to purge dirty SF₆ from components and replace it with clean gas. Therefore, it is desirable to have the capability of repurifying and reusing SF₆ whenever possible.

This report describes the design considerations and intended use of a modified commercial SF₆ gas transfer system. This system will collect, purify, store, and recirculate SF₆ gas for the high-voltage switches used in Sandia's electron beam accelerator programs.

Current Operations

Typically, SF₆ gas is withdrawn from standard 115 lb gas bottles obtained from Sandia stores and is routed through manifolds, regulators, and valves into high-voltage switches. From the switches the gas flows through a control valve and is vented to the atmosphere, outdoors. As can be seen in Figure 1, a typical machine using SF₆ may have three different types of switches and each type of switch may require various pressures of SF₆ gas for operation. Also, because the switches are normally immersed in transformer oil, a positive gas pressure is maintained in the switch at all times to insure that oil will not enter a switch if a leak develops in the switch seals. When a switch is operated, electrical breakdown occurs and by-products are formed in the SF₆. The dirty gas containing these breakdown products must be removed and replaced with clean SF₆. To remove the dirty SF₆ from the switches, the control valve is opened and the dirty gas is forced out by the clean gas from the supply in the 115 lb bottle. After purging for a specified time, the control valve is closed and the switch maintains the pressure selected on the regulator. Purging the dirty SF₆ gas is usually required after each switching operation to insure repeatability of switch characteristics.

Figure 1. Typical SF_6 Plumbing Diagram

Design Background

A suggestion was made by S. L. Shope, 5246, that a considerable savings for Department 5240 might be possible if a system could be designed to reclaim the large quantities of SF_6 gas being vented to the atmosphere during e-beam accelerator experiments. A survey was conducted and it was determined that Department 5240 was using about 525 bottles of SF_6 per year in Tech Area V. The cost to Sandia to refill each SF_6 bottle is \$293.00. Thus, the annual cost to Department 5240 for SF_6 gas is about \$154,000. Accelerators are currently being designed that will require larger quantities of SF_6 for operation and the cost for SF_6 gas is increasing, thereby producing even larger operating expenses. Therefore, it was decided to investigate the feasibility of designing a system to reclaim SF_6 gas and, if economically justified, to purchase such a system.

Design Procedure

The initial approach to this problem was to design a complete system to recirculate the SF_6 gas through a commercial filter bank for repurification and then back into the switches. W. J. Andrzejewski, 5821, and W. E. Stocum, 3311, were requested to analyze samples of SF_6 gas, taken from electron beam accelerators in use in Tech Area V, to determine the breakdown products causing unsatisfactory operation of the switches. From the results of this analysis the type of filters required to remove these impurities could be purchased and a system designed around the available filters. Samples of SF_6 were taken before and after switch operation and the impurities identified

were those commonly expected in SF_6 and its breakdown products,³ i.e., CF_4 , H_2O , N_2 , O_2 , etc. With this information, a survey of filter and gas scrubber manufacturers and high-voltage component manufacturers as well as other research facilities was begun in an attempt to select the best filtration system on which to base our design. In the course of this survey, it was learned that Pall Trinity Corporation had built SF_6 transfer systems for use by electric utility companies to reclaim SF_6 gas from high-voltage circuit breakers, and that they had also built an SF_6 gas conditioning system designed by Physics International for an accelerator operated by Harry Diamond Laboratories near Washington, DC.⁴ Further investigation revealed that Pall Trinity no longer was in the SF_6 gas handling field, but had sold their rights to Limco Manufacturing. After reviewing the operation manual for the SF_6 system designed by Physics International and discussing its operation and maintenance with Mr. Dennis Linsgy at Harry Diamond Laboratories, it was decided that specifications should be prepared and a system ordered. It was noted that the unit in use at Harry Diamond had similarities with commercial units in the filter, dryer, storage, and recirculation components. Therefore, it was decided that with some modifications a commercial SF_6 gas transfer cart, manufactured by Limco and others for use by utilities, could be used for our application. The design specifications were prepared to be as compatible as possible with the commercial units.

The SF_6 system (Figure 2) was designed to bypass, but not eliminate, the standard 115 lb SF_6 gas supply bottles. The system will supply clean SF_6 gas at a constant predetermined pressure (300 psig max) to the same manifold that the bottles are currently supplying (Figure 3). The system also was designed to have a gas capacity to permit the operation of up to three accelerators simultaneously. The dirty SF_6 gas exhausted from the accelerators into the system, at 3 psig max, is repurified by passing it through a 10 μ particle filter, a soda-lime and activated alumina chemical filter, and a dryer. Up to 1650 lb of SF_6 can be stored in the gas and/or liquid state in the system storage tank. Gas in the system storage tank can be recirculated through the filtration units, via a closed loop, for additional purification. A vent valve is provided at the top of the storage tank to purge any noncondensable gases from the system and a sight glass is mounted on the tank to monitor the level of liquid SF_6 in the tank. A float-type level indicator is also provided in the storage tank to remotely monitor the liquid SF_6 level. An elapsed-time meter is attached to the compressor to monitor the compressor operation. A valve display panel with indicator lights is provided to enable an operator to quickly verify and monitor valve positions for the various functions of the system. The system is also capable of adding SF_6 directly to the system from standard 115 lb gas bottles, and for filling empty 115 lb bottles from the system storage. A vacuum pump is provided for evacuating containers, to remove unwanted gas, before backfilling with clean SF_6 . The system operates on 208/240 VAC 3 ϕ , 60 Hz, and requires 20 kW of power. The recommended operating temperature range for the system is -20° to 100°F ; however, the system will operate beyond this range at a reduced efficiency. The system is (in inches) 59.5 H x 123.5 W x 58.5 D, it is mounted on casters, and is enclosed in a weather-resistant metal housing for use outdoors.

Figure 2. Picture of SF₆ System

Figure 3. SF₆ System Diagram

Conclusions

As a result of our investigation we concluded that SF_6 gas can be reprocessed using commercially available equipment modified to meet our specifications. The cost of this equipment is modest when compared to the annual expense of venting contaminated SF_6 , as is currently being done, and we estimate that we can recover this cost after approximately six months of operation. A system has been ordered and will be installed and in operation about March 1978. A follow-up report will be issued, after installation and checkout, to discuss the cost savings and results of operation of this system on the e-beam accelerator experiments.

References

1. D. L. Johnson, "Initial Proto-II Pulsed Power Tests," Proceedings of IEEE International Pulsed Power Conference, Session, IE-2, November 1976.
2. "Particle Beam Fusion," in SAND76-0615, Sandia Laboratories Technology Report, October 1976.
3. Memos from W. J. Andrzejewski - 5821 to G. E. Staller - 5243, dtd November 2, 1976 and February 15, 1977; Memo from D. R. Parker - 3311 to G. E. Staller - 5243, dtd December 17, 1976; and "Sulfur Hexafluoride for Gaseous Insulation," Report TB-85603, Allied Chemicals, General Chemical Division.
4. "The Aurora Prompt Gamma Flash Simulator Gas Conditioning System Operation and Maintenance Manual," PIMM-225-V, Physics International Co., June 1972.

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