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SF₆ Tracer Gas Tests of Bagging-Machine Hood Enclosures

By Robert P. Vinson, Jon C. Volkwein,
and Edward D. Thimons



UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

Page

Abstract..... 1
Introduction..... 1
Tracer gas test method..... 3
Tracer gas tests at first bagging facility..... 3
Tracer gas tests at second bagging facility..... 6
Tracer gas tests at third bagging facility..... 8
Conclusion..... 10

ILLUSTRATIONS

1. Typical hood enclosure..... 2
2. SF₆ sampling and release locations during bagging..... 2
3. SF₆ sampling and release locations when not bagging..... 3
4. First bagging facility..... 4
5. First SF₆ test--no bagging..... 5
6. SF₆ comparisons of bagging and no bagging..... 5
7. Hood modifications..... 6
8. Tests of hood modifications..... 7
9. SF₆ comparisons of first and second bagging facility..... 7
10. Hoods of third bagging facility..... 9

SF₆ TRACER GAS TESTS OF BAGGING-MACHINE HOOD ENCLOSURES

by

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ABSTRACT

This Bureau of Mines report presents the results of tracer gas studies conducted at three facilities where bagger hoods had been installed several years ago to remove airborne silica dust from the vicinity of the bagging operator. The studies indicated that for optimum benefits makeup air must be evenly dispersed, the hood enclosures and duct systems must be as airtight as possible, the average intake air velocity of each hood should be at least 200 fpm, and the hoods and duct systems must be properly maintained.

INTRODUCTION

Studies by the Bureau of Mines have shown that bagging silica products exposes workers to hazardous concentrations of silica dust. In an effort to reduce these concentrations, the Bureau has made a number of modifications to bagging machines. One of these is to enclose each station of the bagging machine with an especially designed hood (fig. 1). The enclosures have interconnecting duct work which runs to an exhaust fan and dust collector. The fan pulls the dust-laden air that forms in and around the enclosures through the duct work and into the dust collector, thus keeping silica dust away from the bagging-machine operator.

Measurements made immediately after a number of modifications were made to a bagging machine showed that dust concentrations were reduced. However, these measurements did not show the effectiveness of the hood enclosures alone, nor was it known how well the hoods would function over a long interval of time. To provide this information, a series of tracer gas studies were recently conducted by the Bureau at three bagging facilities where hood enclosures had been installed about 3 years before. The objectives of these tests were to determine how effectively the hoods removed dust-laden air, and how modifications to the hoods affected their efficiency.

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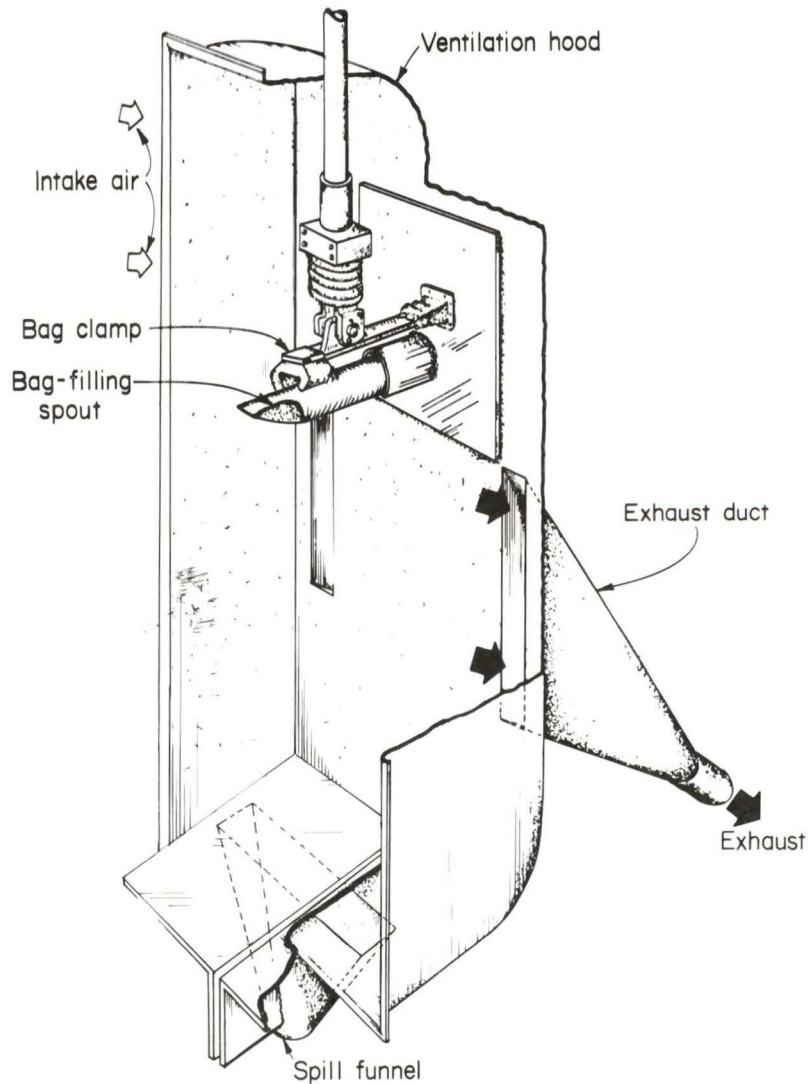
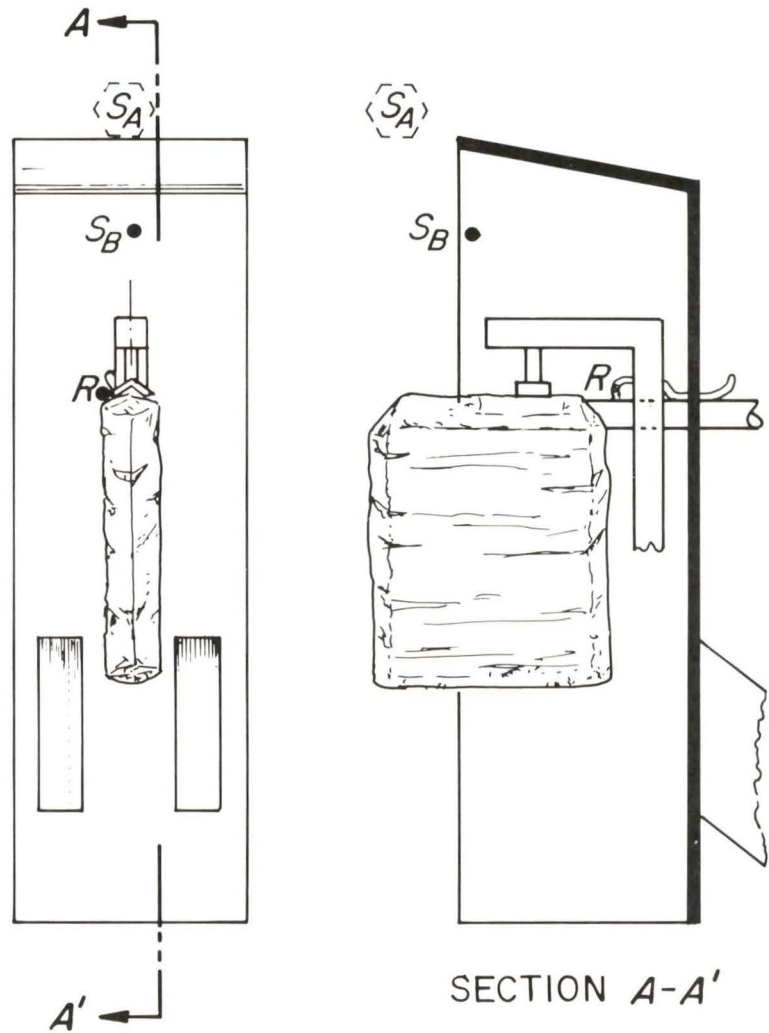


FIGURE 1. - Typical hood enclosure.



KEY
 S_A, S_B — Air sampling location
 R — SF_6 release location

FIGURE 2. - SF_6 sampling and release locations during bagging.

TRACER GAS TEST METHOD

The ventilation efficiency of the bagger hoods was evaluated by releasing sulfur hexafluoride (SF_6) at a constant rate inside the hood and periodically taking air samples in the vicinity of the hood. At the start of the test, tracer gas was released at 0.25 scfh inside the hood, through a plastic tube perpendicular to and pointing at the back end of the loading spout. Air samples were taken 1 minute later and continued at 1-minute intervals for 5 or 8 minutes. Figure 2 shows the air sampling locations S_A and S_B when the operator was bagging silica products. Location S_A is the breathing zone of the operator. When the operator was not bagging, air samples were taken at the locations shown in figure 3. Both figures 2 and 3 show the SF_6 tracer gas release location at R. Before and after each tracer gas test air samples were also collected around the bagging machine, to determine any background SF_6 level.

Ideally all the SF_6 released should be removed by the exhausting air

system connected to each hood enclosure. If the hood enclosures are working as designed, no SF_6 is measured at the air sampling locations.

TRACER GAS TESTS AT FIRST BAGGING FACILITY

The first hood enclosures tested were installed on a fluidizing-type machine used for bagging silica flour (fig. 4). Several modifications had been made to this facility to reduce the silica dust hazard. The four-nozzle bagging machine was enclosed in a room made of plywood which had two doors made airtight with rubber gaskets and two openings for a conveyor to remove filled bags. The room also had exhaust and makeup air systems. The exhaust system pulled air from above the conveyor, from a hopper under the machine, and from each of the four hoods, into a baghouse. The average velocity of the air entering the hoods was 120 fpm.

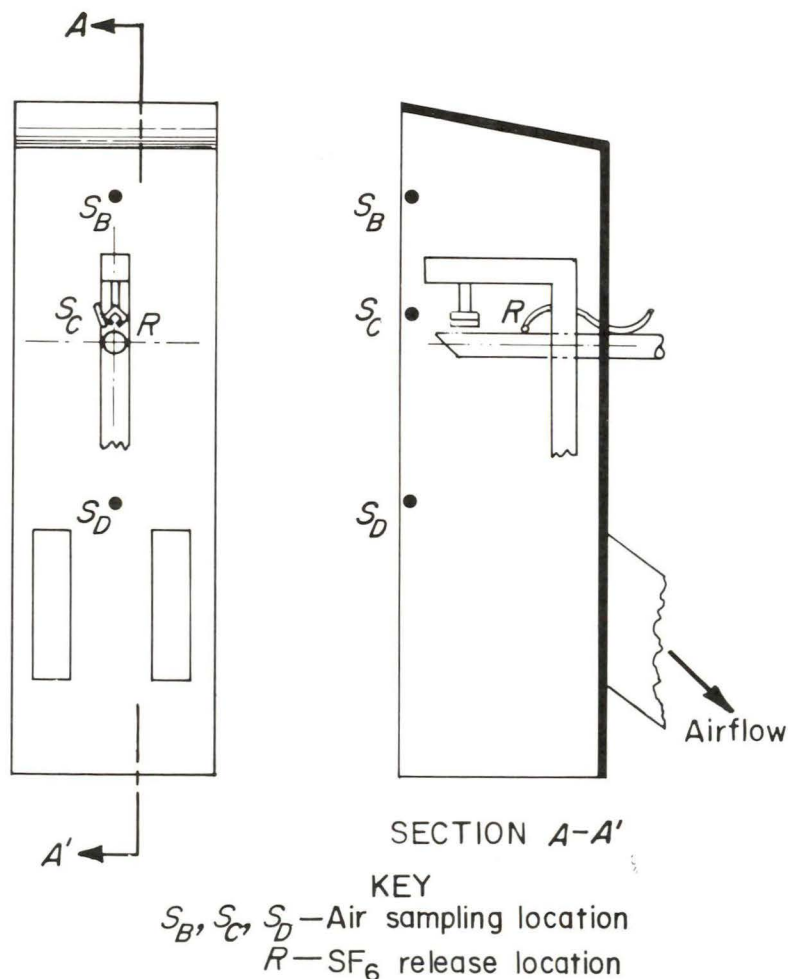


FIGURE 3. - SF_6 sampling and release locations when not bagging.

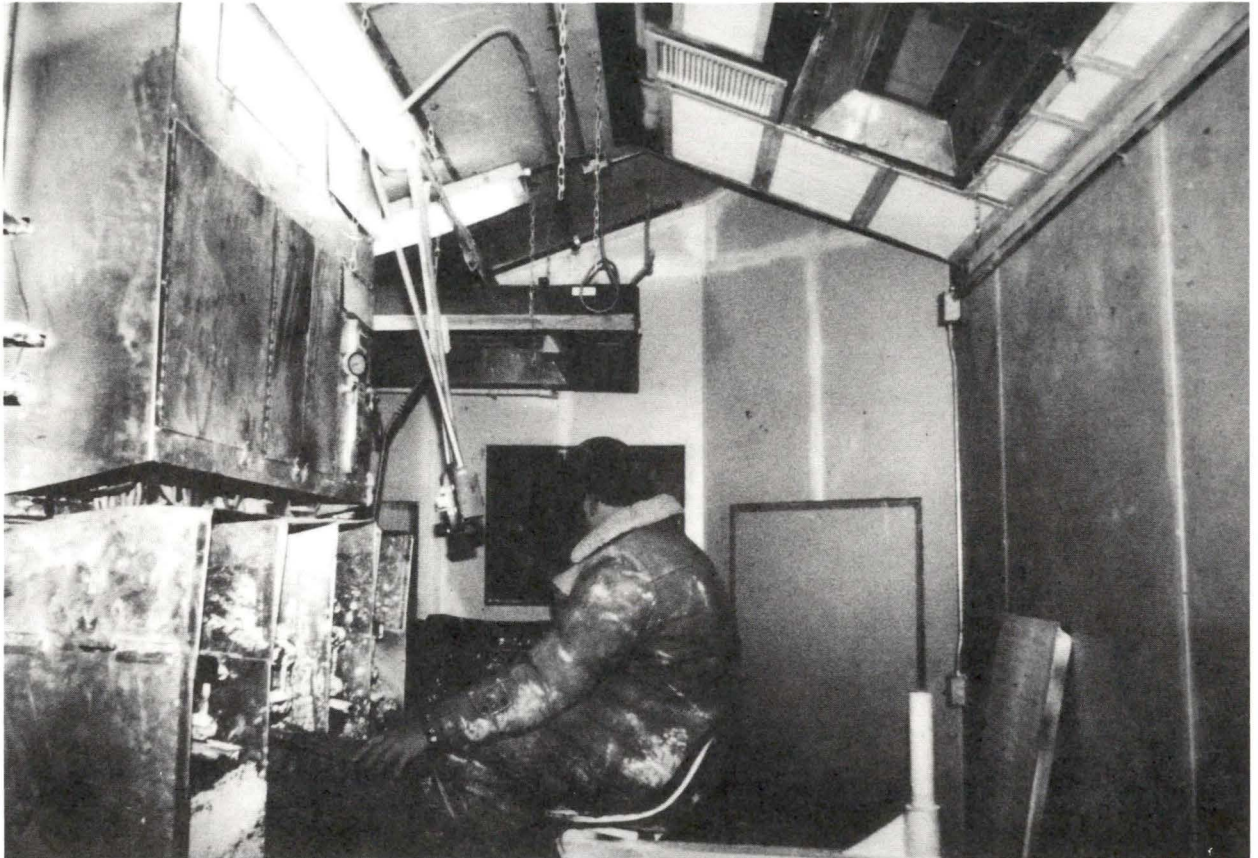


FIGURE 4. - First bagging facility.

The makeup air system replenished air in the room through grillwork in the roof. Jets of makeup air from the grillwork were directed into the hood, producing a turbulent airflow that forced dust-laden air out of the hoods into the bagging room. The action of the air jets is apparent in the first tracer gas test (fig. 5). Tracer gas was released at the back of the hood and detected at all three sampling points throughout the test. This meant that air from the hood was being recirculated in the bagging room.

Since the operator was not bagging during this test, a similar test was conducted during bagging operations and a comparison was made (fig. 6). It was thought that the decreased hood area due to the bag in the hood and the consequent increase in air velocity would help pull the tracer gas into the intake ducts in spite of the incoming jets of air. However, figure 6 shows that this was not the case. Using air samples collected at S_B , the graph shows that SF_6 came out of the hood during bagging, but at a slightly lower rate. Similar concentrations of SF_6 were also measured at the operator's breathing zone.

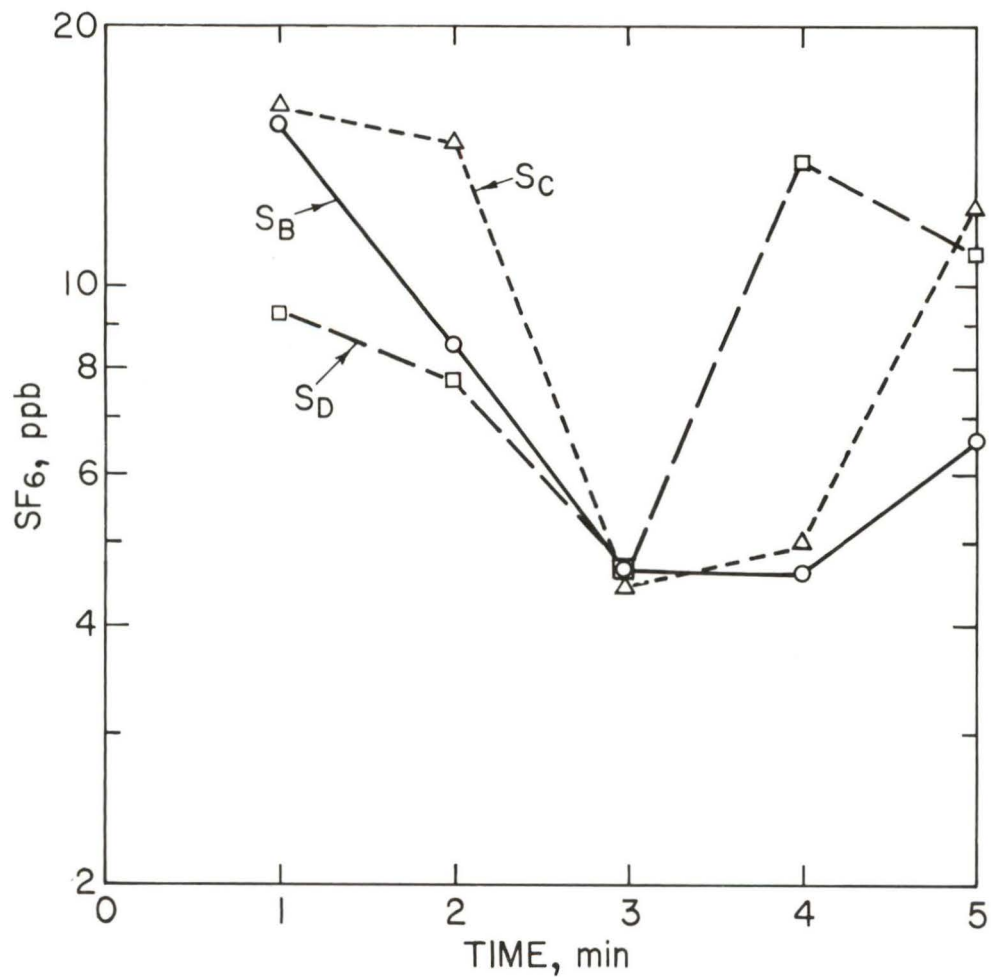


FIGURE 5. - First SF₆ test—no bagging.

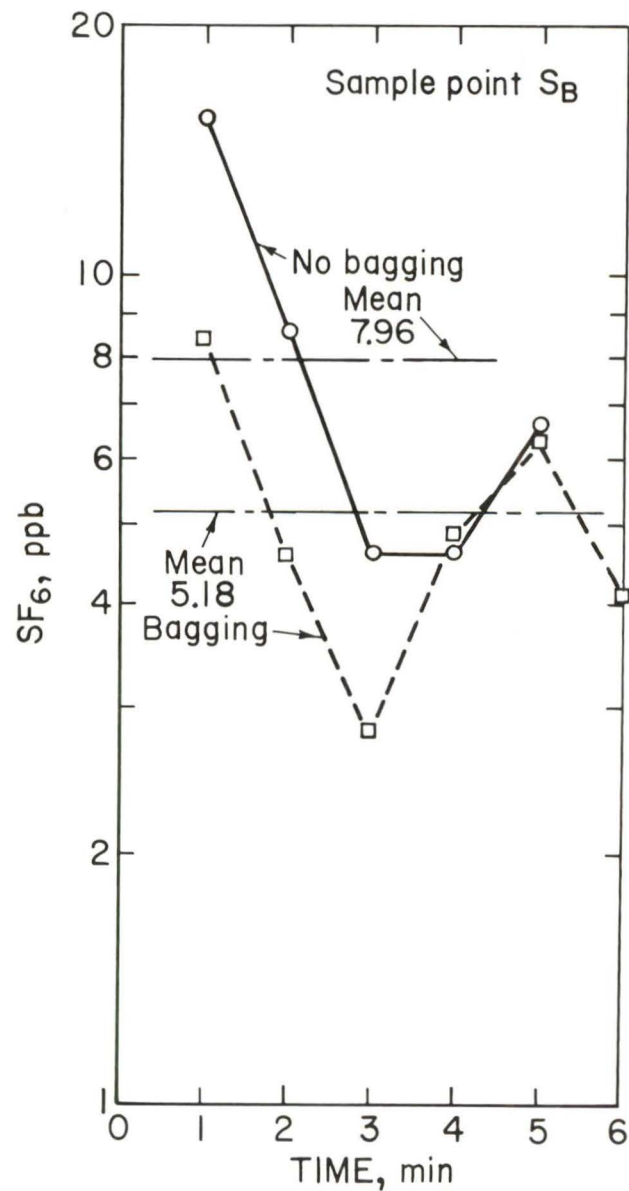


FIGURE 6. - SF₆ comparisons of bagging and no bagging.

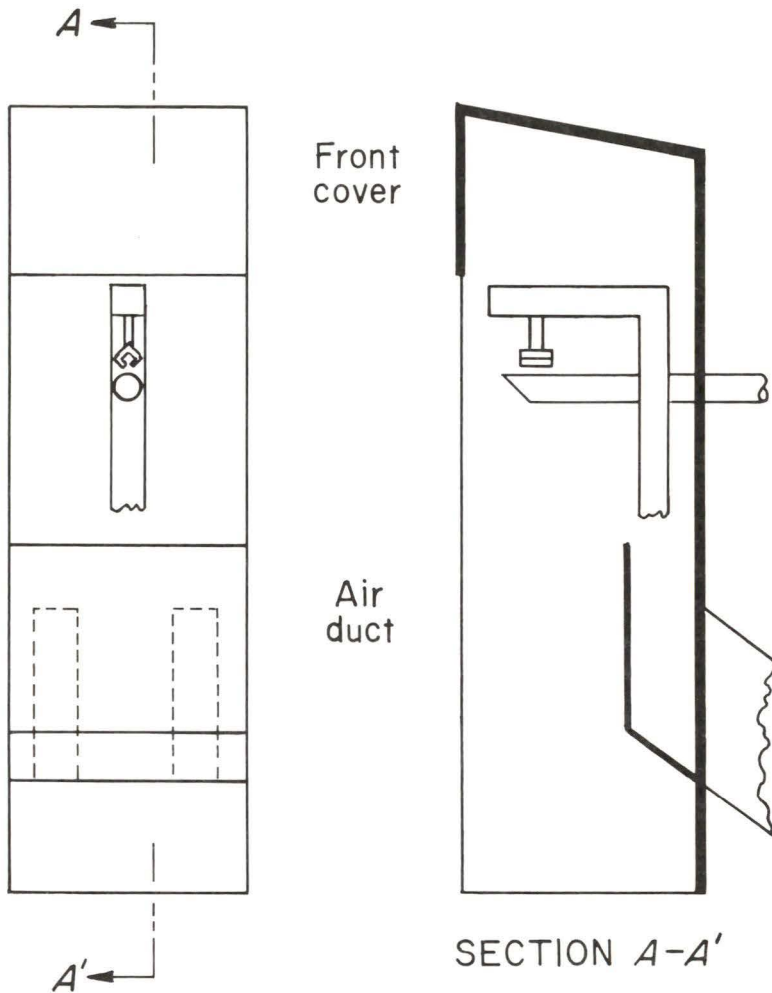


FIGURE 7. - Hood modifications.

like those used at the first facility. In addition the bagging machine was enclosed in a room having exhaust and makeup ventilation systems. The exhaust ventilation system had air inlets at the conveyor, average air velocity at the hood was 95 fpm.

One tracer gas test was conducted during bagging operations and another when no bagging was in progress. Only very small amounts of tracer gas were detected outside the hoods, indicating that they were doing a fairly good job of protecting the operator. The enclosures at this facility were more effective than those at the previous operation because there were no strong air jets from the makeup air system. Results at the two facilities are compared in figure 9. Samples were taken while bagging was in progress. Sample point S_A is the breathing zone of the operator. The presence of tracer gas at this location means the operator was breathing air coming from inside the hood and probably contaminated with silica dust. Figure 9 clearly shows that the operator at the first bagging facility was exposed to more hood air than the operator at the second bagging facility.

Because of conveyor breakdowns, other SF_6 tests were conducted without bagging to determine the effect of adding a top front cover to the hood and running an air duct up the back of the hood (fig. 7). Tracer gas tests were conducted to evaluate the hood cover and the air duct, separately and together. Figure 8 gives the resulting average SF_6 concentrations at each sampling location, as well as tracer gas concentrations with the unmodified hood. The best results were obtained with the air duct alone, which gave the lowest SF_6 concentration at S_B , the sampling point closest to the operator's breathing zone.

TRACER GAS TESTS AT SECOND BAGGING FACILITY

A second series of tracer gas tests was conducted at another facility, where a three-nozzle fluidized bagging machine had been equipped with hoods

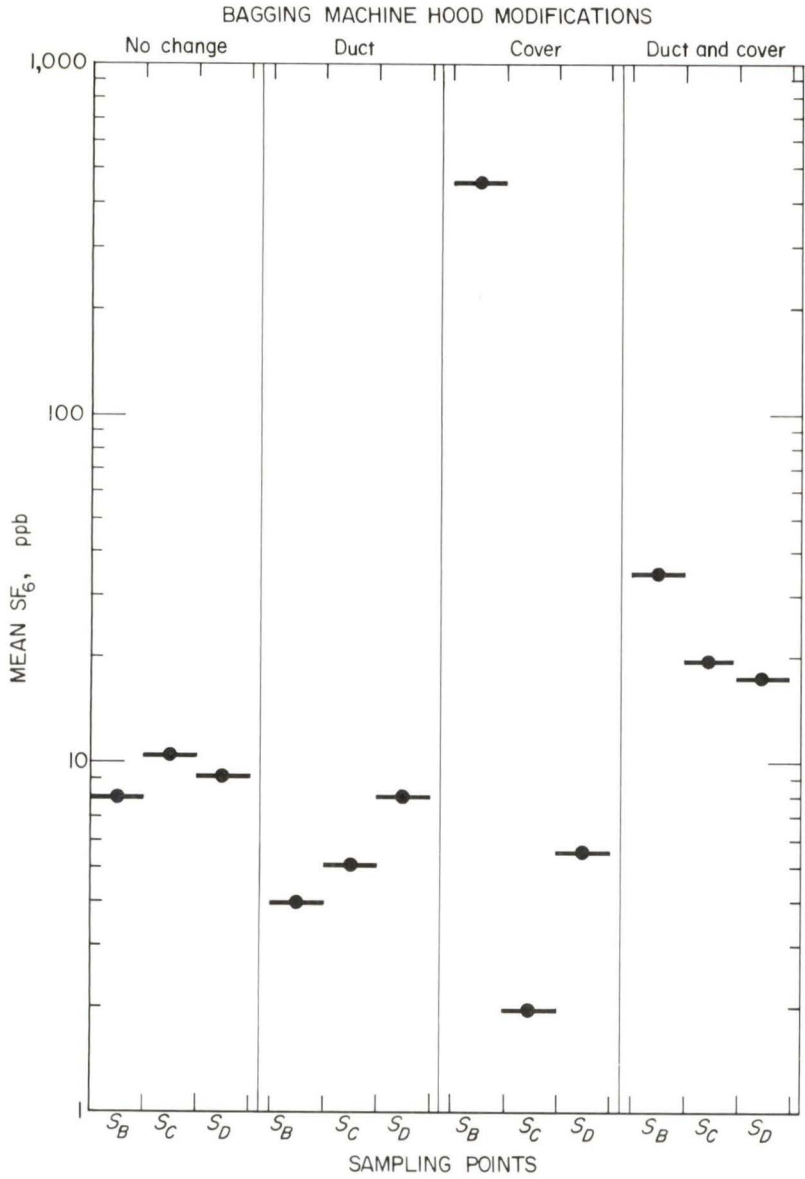


FIGURE 8. - Tests of hood modifications.

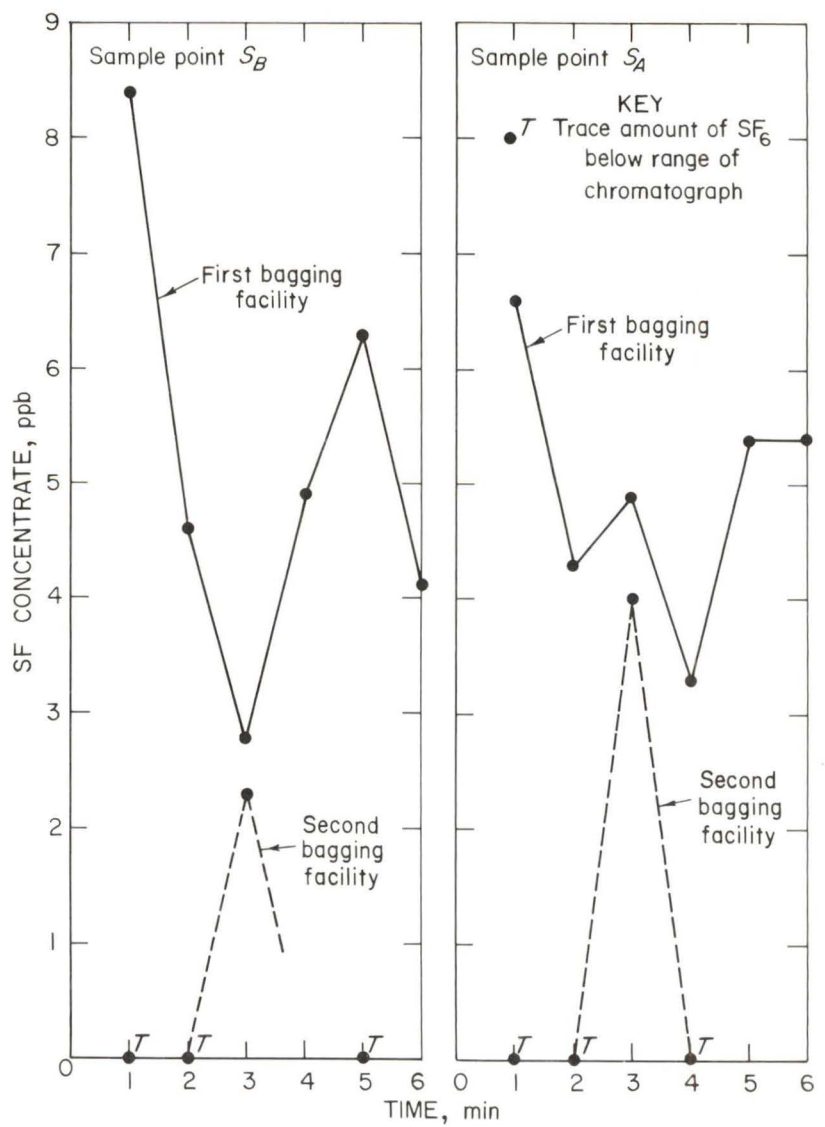


FIGURE 9. - SF₆ comparisons of first and second bagging facility.

Additional air samples were taken at both facilities before and after each test. Generally there was at most only a trace amount of SF_6 detected before each test. Samples taken immediately after each tests showed a buildup of SF_6 in the bagging rooms. At the first facility, this is attributed to air jets which forced air out of the hoods. At the second facility, the buildup of SF_6 is attributed to large gaps in the back of the hoods through which the load nozzle passed; the gaps allowed SF_6 to escape into the room.

TRACER GAS TESTS AT THIRD BAGGING FACILITY

In contrast to the first two facilities, this bagging machine was not enclosed in a room; instead, it was located at one end of a large building used for loading trucks and box cars. The bagging machine had an exhaust ventilation system and collector which exhausted out of the roof of the building. The bagger hoods were well constructed with airtight seals around the loading nozzle (fig. 10). They also had a flared perimeter to reduce the pressure loss of air entering the hoods. The building had a makeup air system.

Five tracer gas tests were run in the same manner as before. No SF_6 was detected at the baggers in the building itself, either before or after the tests. During chromatograph analysis of the air samples, the chromatograph was checked repeatedly with SF_6 calibration gas. Also, the air samples were analyzed twice with the same result. Smoke-tube tests of the hoods confirmed that they worked well. The SF_6 tests also showed this dust removal system created no recirculation, as enough SF_6 was released so that it could be diluted in 5 billion cubic feet of air and still be detectable. Another factor that contributed to the efficiency of these hoods was their high intake air velocity, which averaged 213 fpm at the hood entrance as compared with 120 and 95 fpm at the two other facilities. The third facility is an encouraging example of what can be done if the bagger hoods and ventilation system are properly designed and maintained.

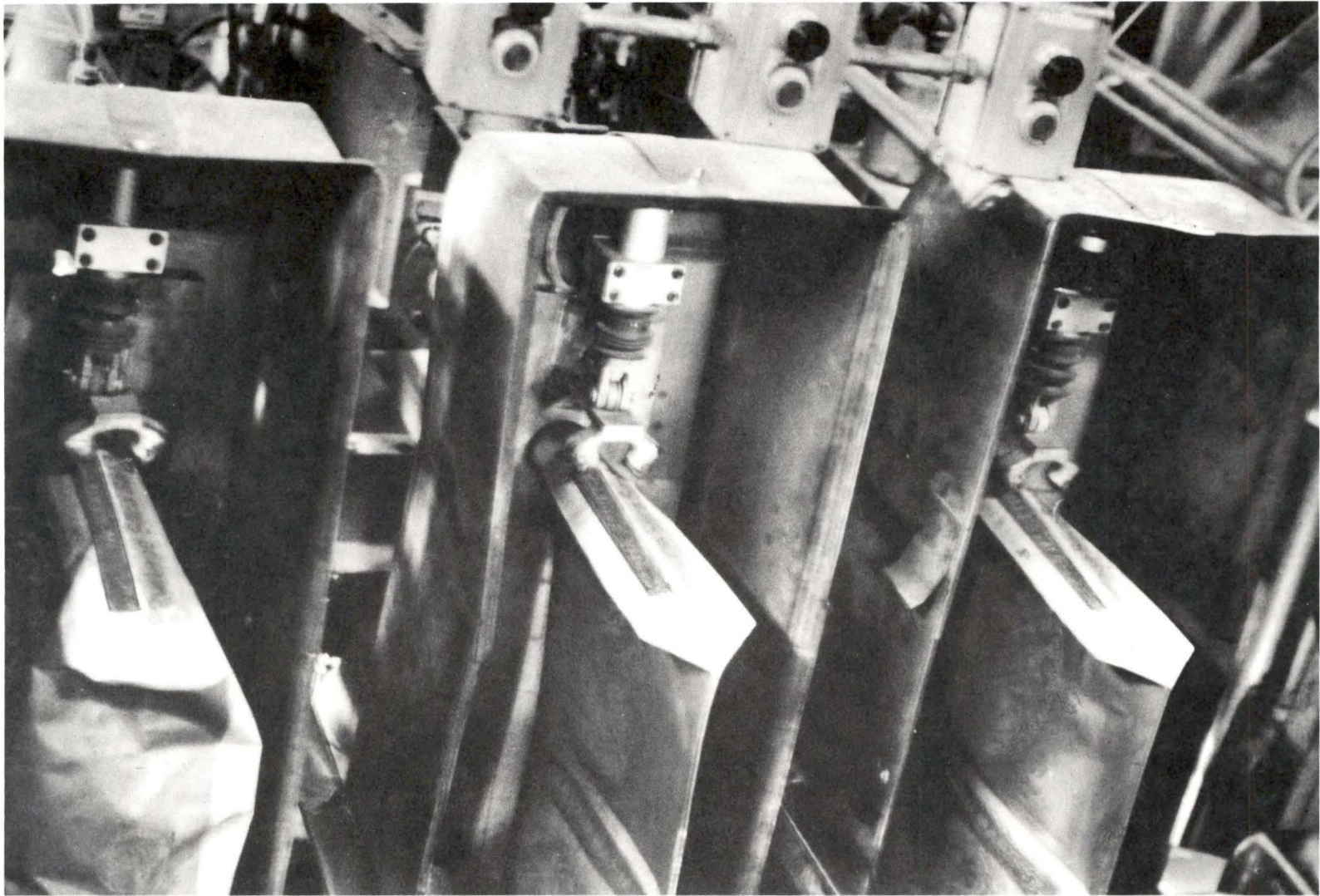


FIGURE 10. - Hoods of third bagging facility.

CONCLUSION

These tracer gas studies of three bagging facilities show that bagger hoods and their related ventilation systems can be an effective method of removing airborne silica dust from the vicinity of the bagging operator. The tests also revealed the following factors to be important in the efficient operation of the hood enclosures; (1) Makeup air must be evenly dispersed and not directed at the hoods as high-velocity air jets; (2) the hood enclosures and duct systems must be as airtight as possible, including the area around the loading nozzle where it passes through the hood; (3) the average intake air velocity of each hood should not be less than 200 fpm; and (4) the hoods and duct systems must be properly maintained.