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BAG MACHINE DUST CONTROLS AND BAG SEALING

Contract H0318013
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16. Abstract

The bagging of dry pulverized products using fluidized air packers creates severe respirable dust problems in many surface mining operations. During bag filling, excess air and product blows by the bag valve/nozzle interface. After bag ejection, dust blows out of the bag valve. During conveying and handling dust is released from the bag valve and dirty bag surface. Overexposure of the bagging machine operator and bag handlers is common.

This report describes the development and testing of a new dust control system for bagging machines. The system features a new bag clamp design to reduce product blowby during filling. A controlled vacuum system removes excess air from the bag before ejection, eliminating the problems after bag ejection and during conveying and handling.

The system has shown significant reductions in dust exposure for both bag machine operators and bag handlers. These reductions are achieved with no significant effect on total mill productivity.

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FOREWORD

This report was prepared by Foster-Miller, Inc., (FMI), Waltham, MA, under United States Bureau of Mines (the Bureau) Contract No. H0318013. This contract was initiated under the Health and Safety Technology Program. It was administered under the technical direction of the Pittsburgh Research Center with Mr. Andrew Cecala acting as Technical Project Officer. Mr. Joseph A. Gilchrist was the contract officer for the Bureau. This report is a summary of the work completed under the contract during the period May 1981 to October 1984. This report was submitted by the authors in November 1984.

The technical effort was performed by the Engineering Systems Group under the direction of Mr. Adi Guzdar, with Mr. Mackenzie Burnett as Program Manager. Major FMI contributors to the effort included: Mr. Joseph Valentine, Mr. Terry Muldoon, Mr. Robert Pokora, Mr. Hans Hug, and Mr. Ron Lundin.

The authors would like to extend their special appreciation and acknowledgement to the numerous mining industry representatives who provided valuable input to the program and who provided valuable assistance during the field evaluations. The assistance, guidance, and cooperation extended by Mr. Andrew Cecala, Mr. John Volkwein, and their staff from the Bureau are also appreciated.

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ES.1 BACKGROUND

Respirable dust exposures in minerals processing plants are strictly limited under the Federal Mine Health and Safety Act of 1977. In many of these plants, the final processing step is packaging a dry, finely pulverized product into 50- or 100-lb paper bags. Fluidized air packing machines are commonly used.

While these machines are fast and efficient, a substantial amount of respirable dust is generated during the bag filling process. The dust is released as:

a. Product blowby during filling - The fluidizing air inflates and pressurizes the bag. The excess air escapes from the bag carrying product between the nozzle and bag valve. This blowby contaminates the operator and bag surface.

b. Product blowing from the bag valve (a rooster tail) as the bag is ejected - Excess air and product discharges from the bag valve as the filled bag is ejected from the fill nozzle. This rooster tail contaminates the operator and the bag surface. Another pulse of dust laden air is released when the bag falls onto the conveyor.

c. Product falls from the filling nozzle after the bag is ejected contaminating the bag surface.

d. Product is released from the bag surface and the poorly sealed bag valve during conveying and handling.

These dust sources overexpose both the bagging machine operator and bag handlers. While many attempts have been made to develop dust controls for these operations, they have not brought these mills into compliance, particularly where the product has high silica content.

FMI, under contract to the Bureau, has developed a new control system for fluidized air packing machines to eliminate these major dust sources.

ES.2 NEW SYSTEM DESCRIPTION

The new system, shown in figure 1, contains a number of differences from a conventional system. The first is an improved bag clamp, designed to reduce product blowby during bag filling. During bag filling, the clamp is pushed down on the top of the nozzle by an air cylinder. The sides of the clamp wrap around and contact approximately 70% of the nozzle, improving sealing between the nozzle and bag valve.

The new system also utilizes a controlled vacuum system to vent excess air from the bag before it is ejected from the nozzle. The product fill tube is enclosed in a second larger diameter tube, in which excess air and dust is vented from the bag. The nozzle exhaust system is powered by an eductor, which uses a venturi effect to exhaust the bag at approximately 50 cfm. A pinch valve controls the exhaust system operation. The exhausted material is piped to the mill's bucket elevator to re-cycle any exhausted product.

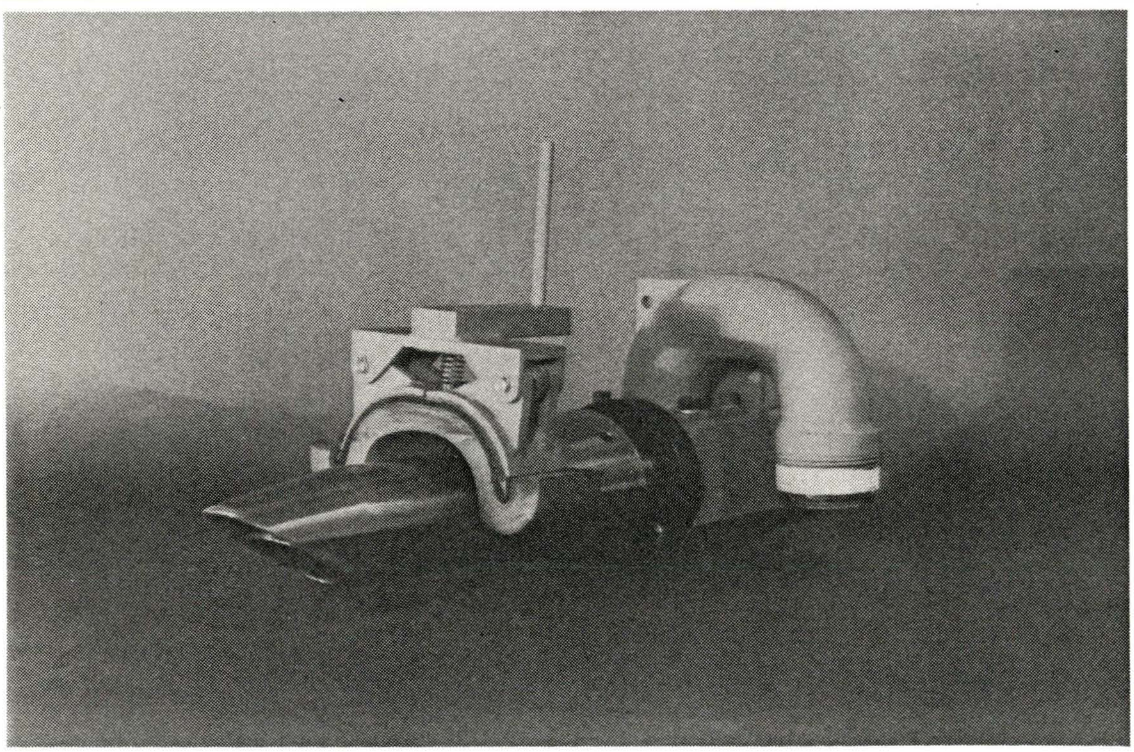


FIGURE 1. - New bagging machine dust control system.

ES.3 NEW SYSTEM OPERATION

System operation, diagrammed in figure 2, is totally automatic with three operating steps:

a. Step 1: The operator places a bag on the fill nozzle and pushes the start button. The bag clamp closes, the product valve opens, and the bag fills as it would with the conventional system.

b. Step 2: When the bag reaches the desired weight, the product valve closes and the suction line valve opens, allowing the bag to be vented. Adequate venting takes approximately 5 s.

c. Step 3: With the vacuum still on, the bag clamp opens and the bag is ejected from the nozzle. The exhaust system continues to operate, cleaning the bag valve as it falls from the nozzle. Two seconds after the bag clamp opens the suction line valve closes, shutting off the vacuum. The next bag can then be placed on the nozzle and the cycle repeated.

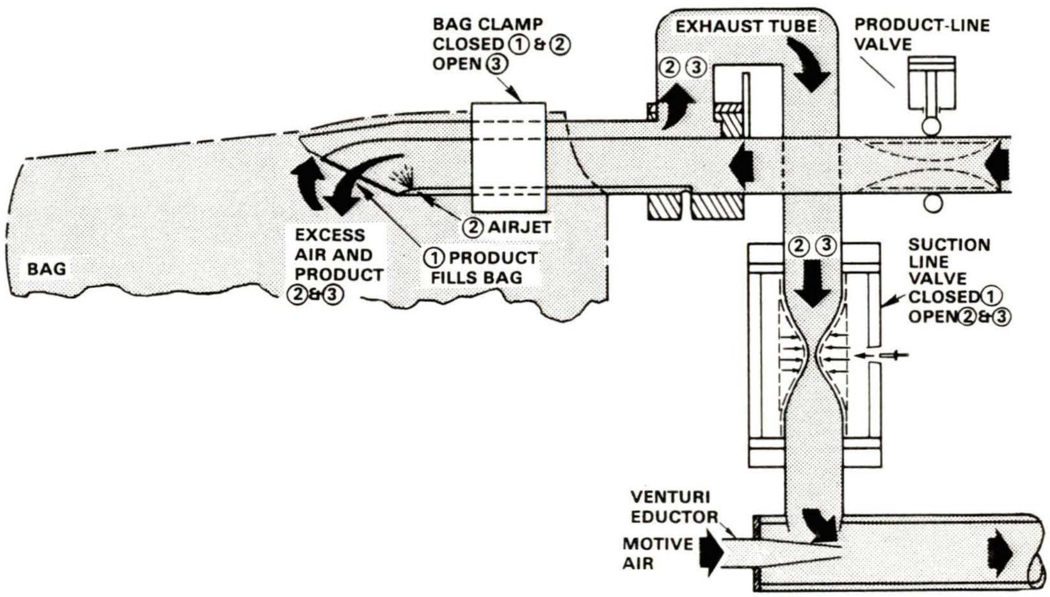


FIGURE 2. - System operation.

ES.4 NEW SYSTEM TESTING

The new system was installed and tested on four station bagging machines in two plants producing ground silica. Each 2-week test period consisted of 1 week of testing with the mill's conventional system, installation of the new system over the weekend, followed by 1 week of testing with the new system. System installation took an average of 27 manhours.

During the testing of each system, instantaneous dust monitors were used to measure respirable dust levels at several key locations:

a. Bagging machine primary exhaust duct to measure total respirable dust generated by blowby during bag filling and rooster tail after bag ejection

b. Bagging machine operator to measure his respirable dust exposure

c. Conveyor transfer and loading area to measure dust levels generated during bag conveying and handling.

Dust level data were continuously recorded using a data logger and strip chart recorders during normal bag filling and loading operations. Productivity was also monitored for both the conventional and new systems.

Table 1 summarizes the results of both field evaluations during the processing of -325 mesh ground silica. At the first field evaluation site, the emphasis was on sampling the bag filling and conveying areas. At the second site, greater emphasis was placed on the bag loading area.

TABLE 1. - Field evaluation respirable dust results

Test site A		Test site B	
Sample location	Respirable dust reduction, %	Sample location	Resirable dust reduction, %
Operator	83	Operator	64
Conveyor transfer	61	Conveyor transfer	84
Exhaust	89	Loading (enclosed trailer truck)	90

The new system significantly reduced product blowby during bag filling and the rooster tail after bag ejection. Dust levels in the primary exhaust from the bagging station were reduced by 89% at site A.

Significant reductions in operator dust exposure were also achieved. The reduction in operator exposure achieved with the new system at site A is graphically illustrated in figure 3, which shows a portion of the strip chart recordings for both the conventional and new systems. The levels for the new system are consistently lower with much less fluctuation than those for the conventional. The approximate threshold limit value (TLV) for the bagging machine operator (0.17 to 0.20 mg/m^3) is shown by the dotted line on the graph. The new system's respirable dust levels are consistently below this limit.

Dust level reductions of 61% and 85% were achieved at the conveyor transfer point for sites A and B respectively. The new system significantly reduced bag surface contamination and product leakage from the bag valve during bag conveying.

Cleaner bags and less valve leakage also produced a significant reduction in dust levels during loading. A 90% reduction in dust levels was measured at site B during the stacking of 100-lb bags inside an enclosed trailer truck.

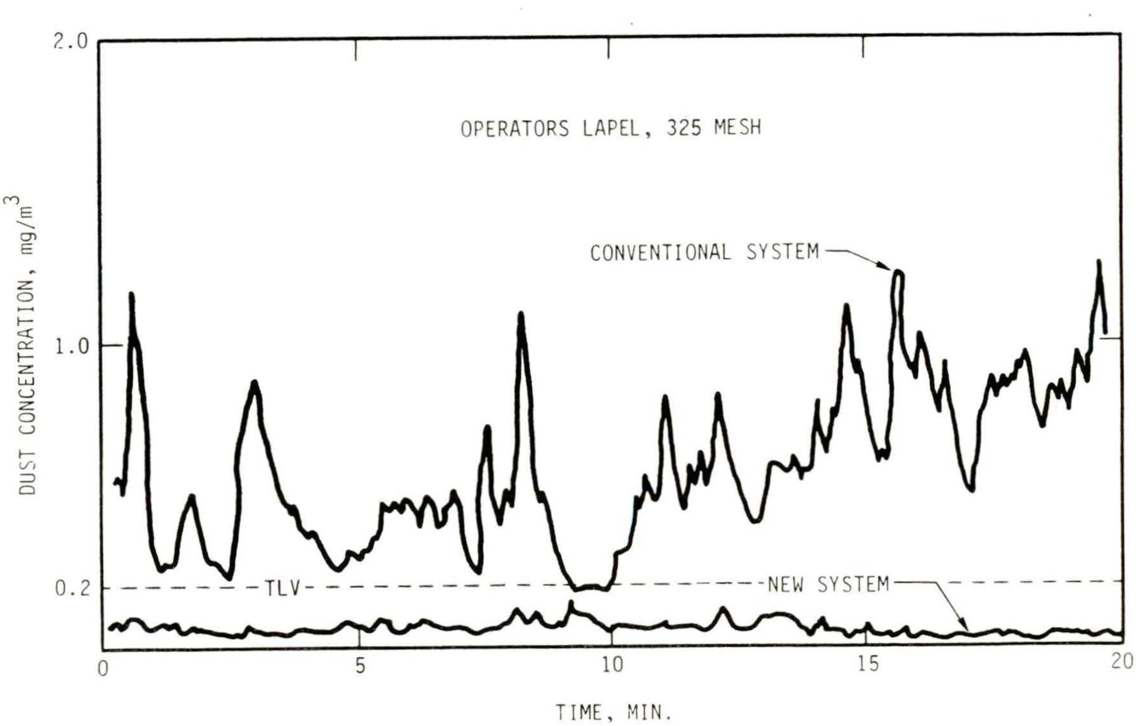


FIGURE 3. - Dust levels recorded at the bagging machine operator while bagging -325 mesh product.

The new system had no significant affect on the total productivity of either plant. At site A, where bag ejection was automatic, the new system increased the time approximately 1.5 s/bag over the conventional system. The delay increased the total loading time per truck (480 bags) by approximately 12 min at site A. At plant B, where the operator pulled the bag from the nozzle by hand, there was no increase.

ES.5 CONCLUSIONS

The new dust control system significantly reduced the dust problems associated with fluidized air bagging machines. The new clamp design reduces product blowby during bag filling. The new nozzle vent system removes excess air from the bag before ejection, eliminating the rooster tail and leakage from the bag valve during conveying and handling. The new system also reduced bag surface contamination.

These improvements resulted in much lower respirable dust exposures for both the bagging machine operator and the bag handlers. These improvements were achieved without a significant impact on either mill's productivity.

1. INTRODUCTION

This document is the final technical report for United States Bureau of Mines (the Bureau) Contract H0318013 "Bag Machine Dust Controls and Bag Sealing," summarizing the effort expended and the results obtained. This report presents the details of the development of a novel dust control system for bagging machines used in the minerals processing industry, the results of two field evaluations of the system, and the details of an evaluation of commercially available bag valves.

1.1 BACKGROUND

The Federal Mine Health and Safety Act of 1977 established strict limits on respirable dust exposures in the mining industry. The allowable limits are particularly low when the respirable dust contains silica. When high silica content is present, the limits may be as low as 0.1 - 0.2 mg/m^3.

In many surface mills, the final processing step is packaging a dry, finely pulverized product in 50- or 100-lb paper bags. Fluidized air or screw-type packaging machines are most commonly used for this operation. Fluidized air machines are usually used for bagging very fine products where the top size may be -325 mesh or smaller. Screw-type machines are typically used for coarser products.

The filling process for a fluidized air machine is quite standard. A multi-ply paper bag, with a simple paper or polyethylene sleeve type valve, is inserted on the fill nozzle of the packer. When the operator pushes the start button, a clamp pushes against the top of the bag to hold it in place, and product flows through the fill nozzle into the bag. When the bag reaches the desired weight, measured with a counter-weight system, the product flow stops and the clamp releases, allowing the bag to fall into a conveyor. The filled bag is conveyed to a loading area where the bags are normally palletized by hand. This process is a quick and efficient way to bag product, but a substantial amount of dust is generated during the filling, conveying, and handling cycle.

The dust generated during the process results from several specific causes:

a. Product blowby during bag filling. Fluidizing air inflates and pressurizes the bag. The excess air pressure is relieved between the nozzle and bag valve. A great deal of product exits with the excess air as shown in figure 4. The dusty air hits the nozzle support structure and rebounds, contaminating the bag surface and the operator's breathing zone.

b. Product blowing from the bag valve (a rooster tail) as the bag is ejected. When the clamp opens and the bag falls away from the nozzle, excess air and product blows from the still open bag valve. This rooster tail of product (figure 5) severely contaminates both the operator's environment and the bag surface. Another pulse of dust laden air is released when the bag hits the conveyor.

c. Product falling from the nozzle after the bag is ejected. The nozzle feed is controlled by a mechanical pinch valve in the rear of the nozzle assembly. Product falls from the nozzle contaminating the bag surface as the bag falls to the conveyor.

d. Product released during conveying and handling. The force of the product inside the bag is supposed to close the bag valve when the bag hits the conveyor. Product in the valve often prevents a tight seal. As the bag is conveyed and handled, excess air and product continues to be released through the valve. Product contamination on the bag surface is also released.

These dust releases during bag filling, conveying, and handling cause dust overexposure for both the bagging machine operator and the bag handlers.

The Bureau, the mineral producers, and equipment manufacturers have implemented a number of programs to develop dust controls for these operations. Results of these efforts have not brought these mills into compliance, particularly where the product has high silica content.

1.2 PROGRAM OBJECTIVES

The primary objective of this contract was to design, fabricate, and evaluate effective system modifications that would reduce dust liberation from the bag-nozzle during bag filling, to eliminate spillage as the bag leaves the machine, and to positively seal the bag. A

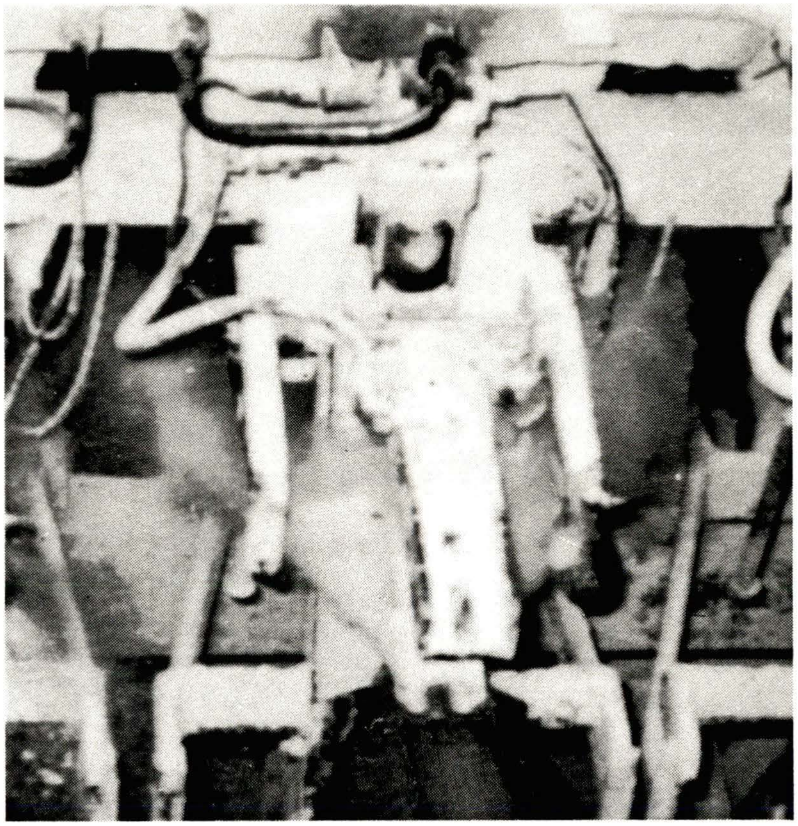


FIGURE 4. - Product blowby between the bag valve and nozzle during bag filling.

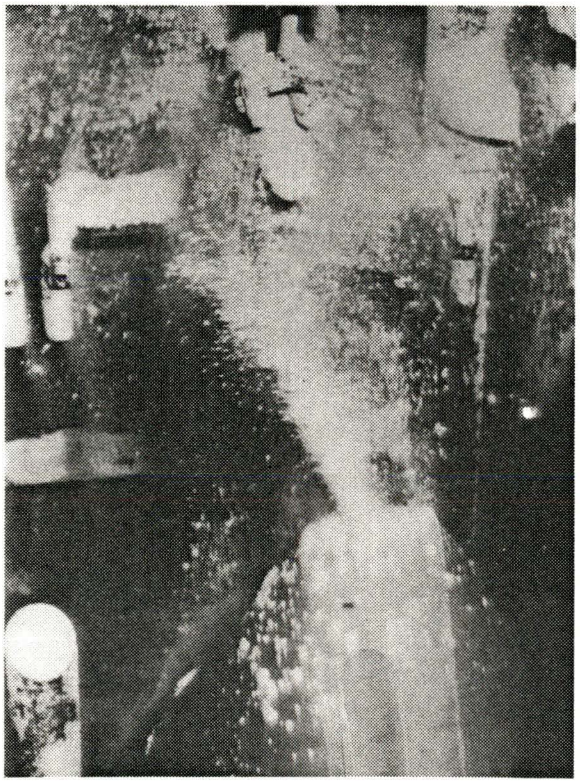


FIGURE 5. - Product blowing from open bag valve "rooster tail" after bag ejection.

second objective, to evaluate the effectiveness of commercially available bag valves in reducing dust liberation during bag handling and stacking, was added by modification of the contract.

2. NEW BAG NOZZLE SYSTEM DEVELOPMENT

The "standard bag nozzle system" on fluidized air bagging machines includes a tapered tube controlled by a mechanical pinch valve. Fluidized product flows into a paper bag placed over the end of the nozzle and held in place by a clamp which traps the bag between the clamp and the nozzle. The full bag is dropped into a conveyor for stacking and loading. The standard system creates several dust related problems:

a. Excess air and product blows by the bag valve/ nozzle interface during filling

b. Excess air and product blows out of the open bag valve as it is ejected from the nozzle and when it lands on the conveyor

c. Product falls from the nozzle after the bag is ejected

d. Excess air and product leaks from the unsealed bag valve during conveying and handling

e. Product contamination on the bag surface is released during conveying and handling.

The bag nozzle system development effort was directed toward reducing or eliminating these problems while maintaining the productivity level of the systems currently in use.

2.1 PRELIMINARY SYSTEM DEVELOPMENT

The preliminary system development focused on two factors:

a. Providing controlled venting for the excess air in the bag. This would reduce product blowby during filling, and blowing out and leakage during bag ejection, conveying, and handling.

b. Eliminating spillage from the nozzle after bag ejection to reduce bag surface contamination.

Several concepts were designed, fabricated, and then tested in a limestone bagging facility in Massachusetts using a two-station, St. Regis force flow packer.

2.1.1 Mechanical Systems

Two nozzle designs, both of which used a mechanical valve inside the nozzle to stop product flow and spillage, were designed, built, and tested. Both designs also included an integral vent to release excess air from the bag.

2.1.1.1 Flapper Closure System

The first system, shown in figure 6, used a flapper type closure to positively stop product spillage after the bag is filled and ejected. The prototype was of square cross-section to minimize flapper fabrication costs at the development stage. Had the concept shown promise, a round design would have been substituted.

The figure shows the flapper valve closed. When a bag is inserted, the flapper is opened by a pneumatic cylinder and product is delivered in fluidized form. Excess air from the bag exits through the bag air vent. When the bag is full, the flapper valve closes, increasing the vent path cross-sectional area to allow bag deflation before ejection.

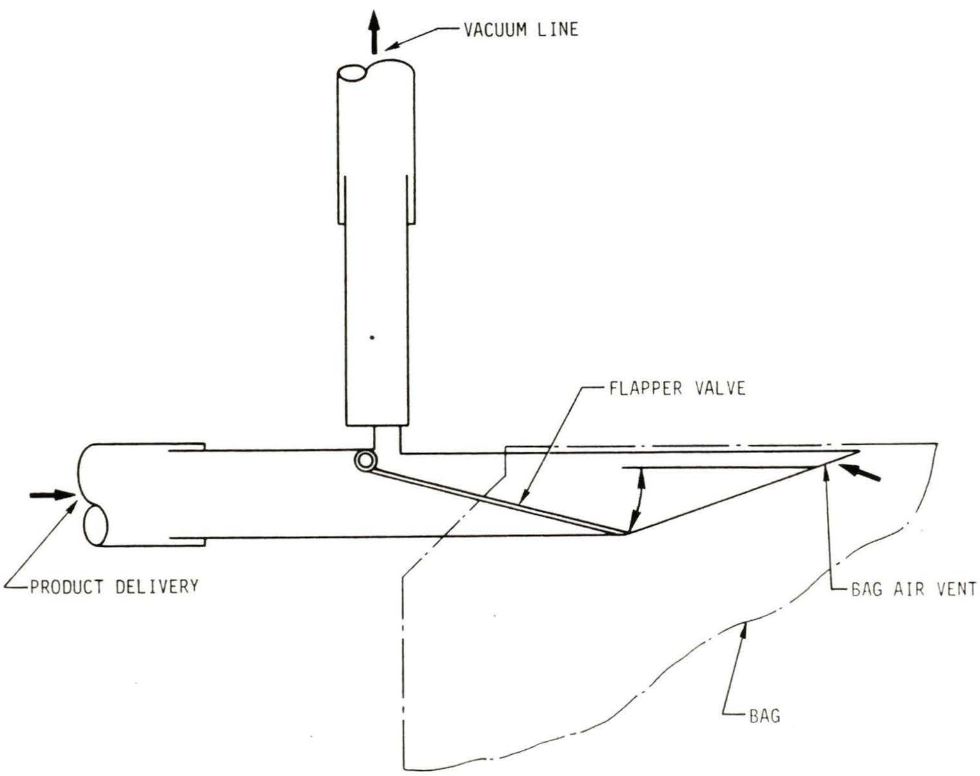


FIGURE 6. - Flapper closure system.

There were several severe problems with this design which caused its rejection. These included:

a. The vent plugged with product

b. The delivered product plugged in the nozzle due to the restriction created by the flapper valve.

Both of these problems were created by the large flow resistances in the respective flow streams. In addition, the product jammed between the flapper valve and the nozzle not allowing it to fully open or close.

2.1.1.2 Butterfly Closure System

The second mechanical system, shown in figure 7, used a butterfly valve to stop product flow and prevent product spillage. The prototype was fabricated with a circular cross-section.

The butterfly valve, like the flapper valve, caused flow restrictions during product delivery. With the valve open, the line plugged all the way into the fluidizer. The restriction created resistance which could not be overcome with the fluidizing system. Since the design is

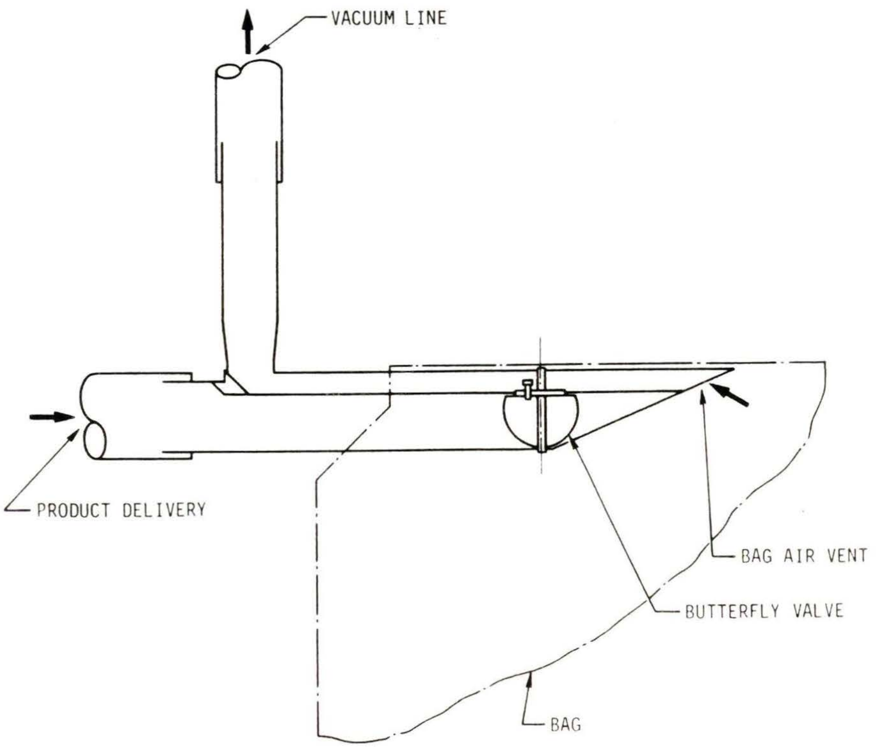


FIGURE 7. - Butterfly closure system.

to be retrofitable at the nozzle station without changes to the fluidizing system, this design was also dropped without further testing.

Since two different designs with mechanical valves to stop flow had been tried without success, the design effort was redirected toward pneumatic schemes.

2.1.2 Pneumatic Systems

The testing of the mechanical systems demonstrated that severe operational problems were created by the use of valves inside the nozzle. The design effort, therefore, was redirected towards schemes which employ airflows to clear the nozzle.

2.1.2.1 Vent and Purge System

The first pneumatic system, shown in figure 8, used a standard nozzle modified with an exhaust air vent to relieve excess air from the bag during filling. Also incorporated in this design was a provision for purging the nozzle with flushing air at the end of each fill cycle, thus eliminating spillage after bag ejection.

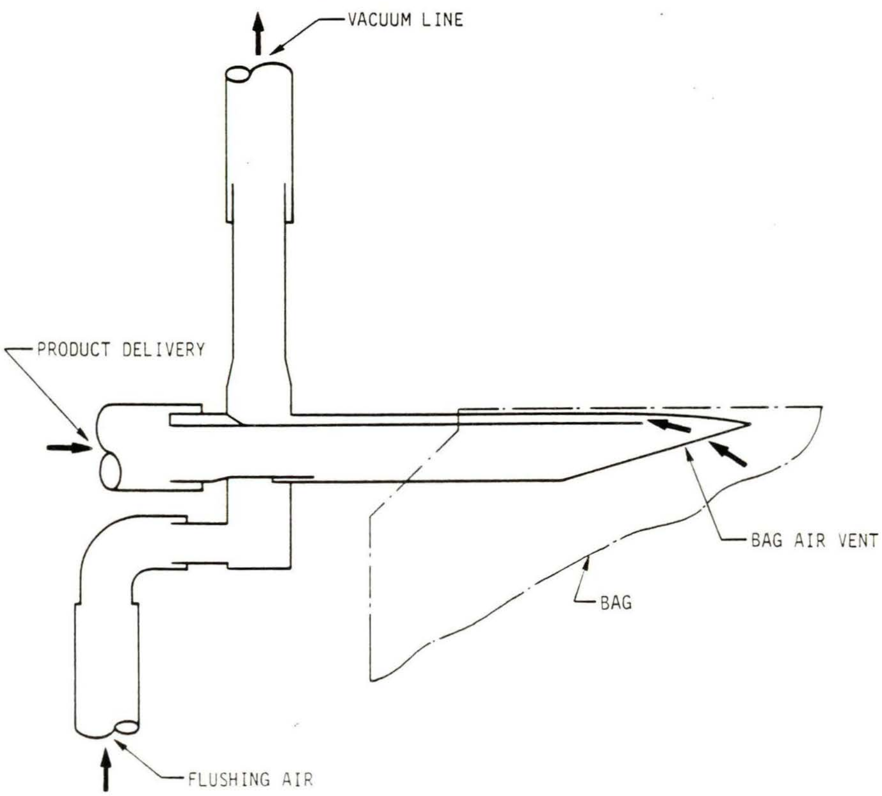


FIGURE 8. - Pneumatic system design no. 1.

The concept was marginally successful in that it demonstrated that air in the bag could be vented and that residual product in the nozzle could be removed. The air in the bag exhausted through the vent slot and the flushing air cleared the nozzle at the end of the fill cycle. However, the vent air slot in this configuration tended to plug before the bag could be evacuated of excess air.

A variation of this concept was tried in which, instead of blowing flushing air, a vacuum was used to clear the nozzle at the end of each fill cycle. Spillage was eliminated but the vacuum pulled excess product from the bag. To use this scheme, the bag would have had to be overfilled by 20 lb to end up at the correct weight.

Testing also showed that the exhaust vent cross-sectional area (flow area) was too small to provide adequate bag venting. Until this point the vent was a circular segment as shown in figure 9a. In an effort to increase venting area and thus reduce flow restriction, the design was changed for the next concept to that shown in figure 9b.

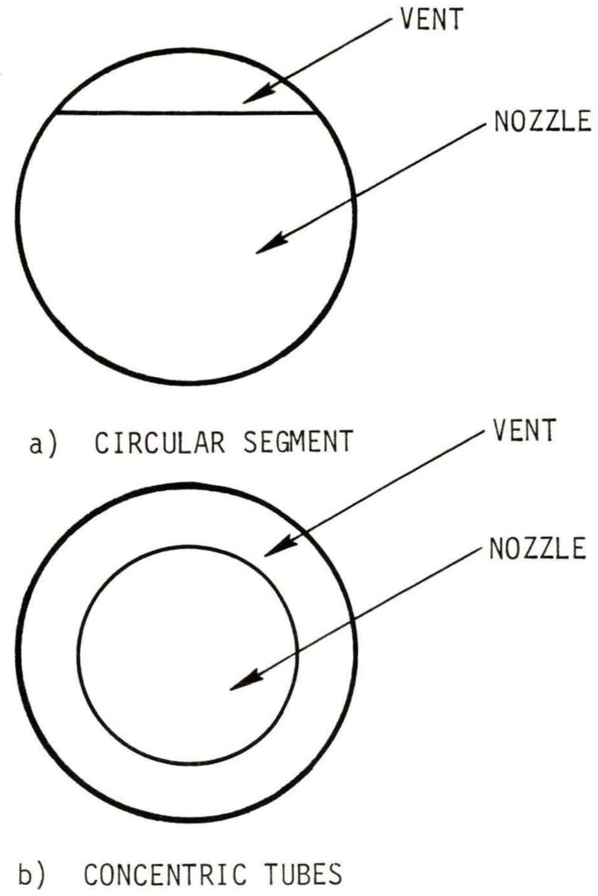


FIGURE 9. - Bag vent designs.

2.1.2.2 Concentric Tube Pneumatic System

The second pneumatic concept used the concentric tube design to increase exhaust vent cross-sectional area. The tube outside diameter was increased from 1.75 to 2 in to accommodate this increased area. This concept, shown in figure 10, incorporated an angled filling tube discharge to direct the product flow toward the bottom of the bag. Fill tube purging was not included.

Three improvements were expected with this design:

a. The larger outside tube diameter was expected to create a tighter fit between the bag valve and nozzle and to reduce product blowby during filling

b. The directed flow was expected to reduce the short circuiting of product into the exhaust vent during filling

c. The larger vent area was expected to improve bag venting during filling and before ejection.

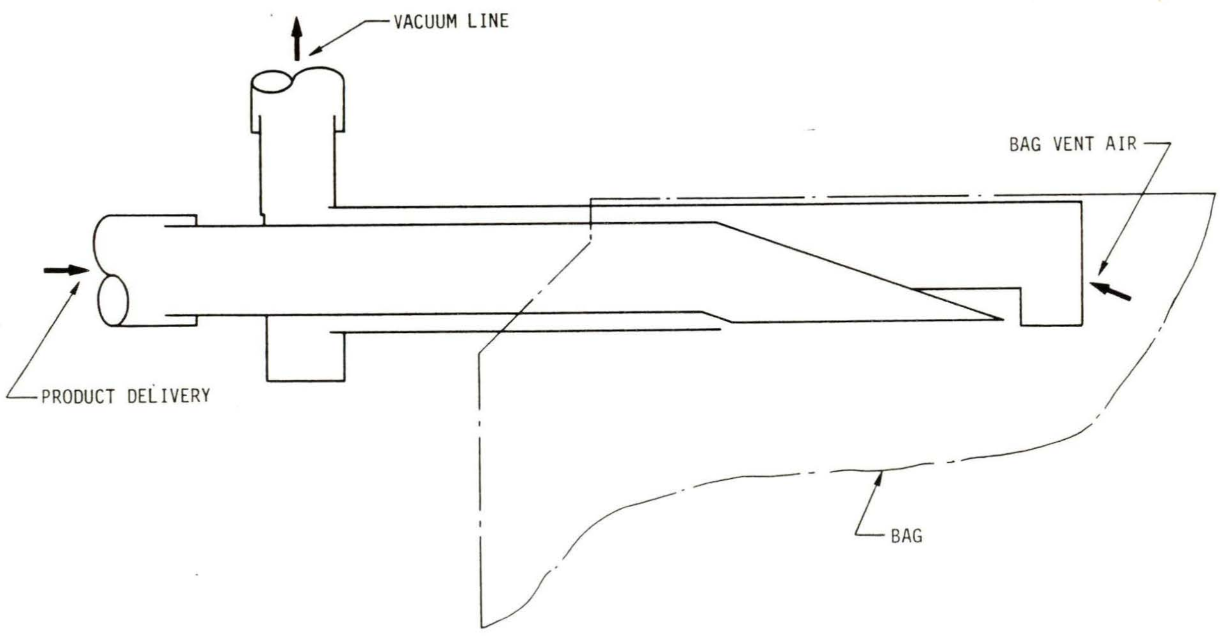


FIGURE 10. - Pneumatic system design no. 2.

Testing of this concept showed the following:

a. The larger tube diameter did not significantly reduce product blowby during bag filling

b. Directing the product flow did appear to reduce product short circuiting to the exhaust vent

c. The vent area still plugged

d. The absence of a fill tube purge resulted in product spillage from the nozzle after bag ejection

e. The bag venting vacuum made the placement of a new bag on the nozzle difficult.

From testing this concept, it was learned that:

a. Improved clamping and a tapered nozzle section to achieve tighter bag valve to nozzle fit would be required to reduce product blowby during bag filling

b. The directed flow of the product may have some beneficial effect and should be continued in the design evolution

c. The vent area must be further increased to prevent vent plugging

d. The venting vacuum must be turned off during placement of a new bag on the nozzle, since the bags tend to stick before they are properly placed

e. Some provision to reduce product spillage from the nozzle is required.

The next design focused on improving the venting system, eliminating product spillage after bag ejection, and shutting off venting vacuum to make bag placement easier.

2.1.2.3 Eccentric Vent Tube Design

This design (shown in figure 11) incorporated the following major features:

a. Eccentric exhaust tube to increase vent area
b. Directed fill tube discharge
c. Tapered cone to reduce product blowby
d. Vent system control to make bag placement easier
e. Fill tube purging to reduce spillage.

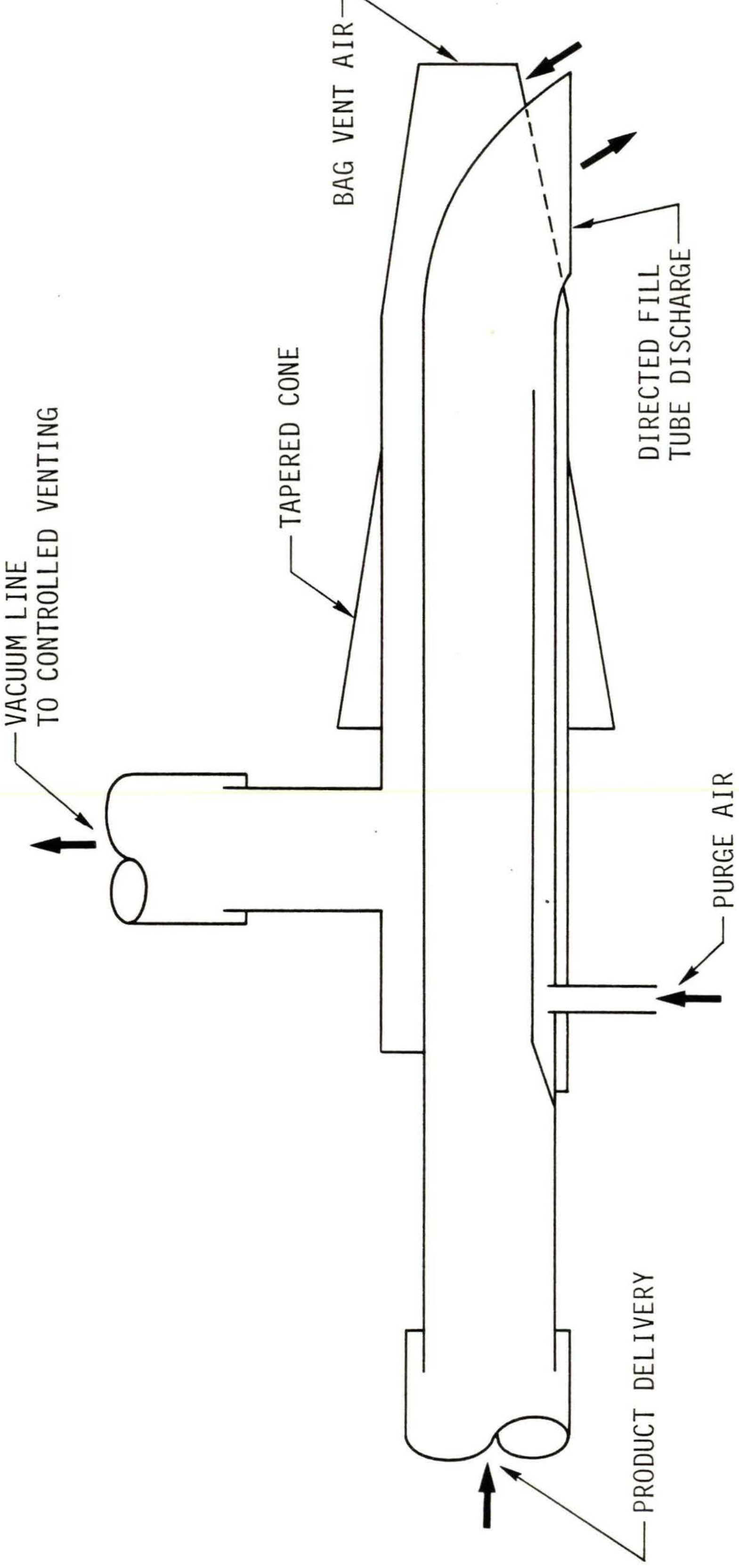


FIGURE 11. - Pneumatic system design no. 3.

Bag venting was through an area created by an eccentric tube within a tube as shown in figure 12. This effectively increased the exhaust tube area. The fill tube was curved at the exit to direct the product discharge downward into the bag. A tapered cone was added to the rear of the nozzle to provide a tighter fit between the bag valve and the nozzle.

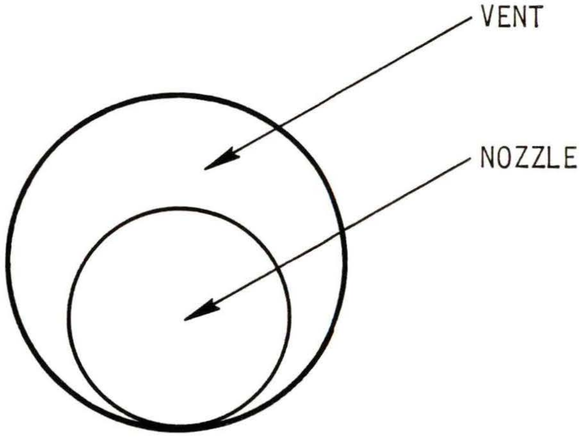


FIGURE 12. - Eccentric vent tube detail.

The vent system is controlled by a slide valve as shown in figure 13. Vacuum is provided by a vacuum blower. During bag filling, the slide valve is open. Air and dust pass through the nozzle vent system due to the bag pressure being slightly higher than atmospheric. When the bag reaches design weight, the slide valve closes as shown, allowing the remaining bag air and product left in the delivery tube and on the bag valve to be vacuumed at the rate of 150 cfm, requiring about 3 s. As the bag is ejected from the nozzle, the slide valve again opens so that the next bag can be inserted without collapsing around the nozzle body due to vent suction.

During the entire cycle purge air is fed at a very low rate. This purge air blows material from the fill tube that would otherwise fall onto the outside of the bag during bag ejection. The purge air is left on continuously to simplify the control scheme even though it is only needed at the end of each cycle.

Testing of this system in the limestone plant demonstrated the following positive results:

a. Excess air was effectively removed from the bag at the end of the fill cycle, virtually eliminating the "rooster tail" from the bag valve after ejection

b. Spillage from the nozzle after bag ejection was significantly reduced.

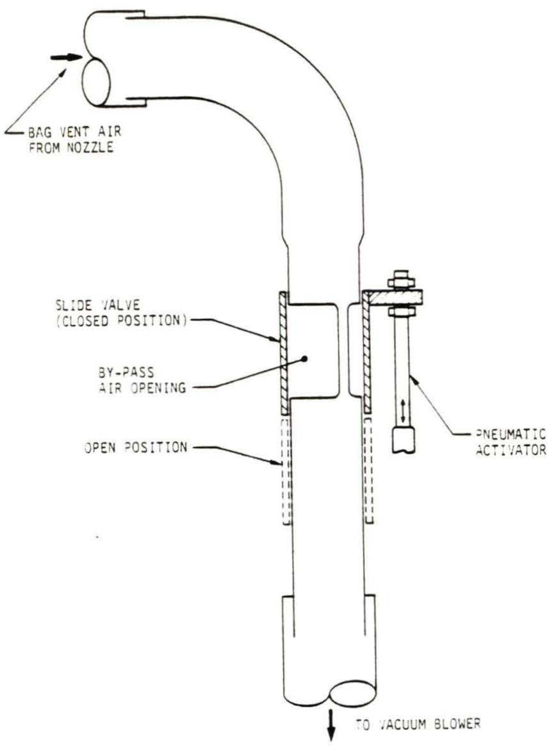


FIGURE 13. - Sliding valve vacuum control design.

Some problems remained, however, including:

a. The tapered cone did not significantly reduce product blowby during filling

b. The centrifugal blower used to provide the required vacuum could not handle the high product loading in the vented air and tended to choke.

The concept was then subjected to preliminary testing in a silica mill, bagging products as fine as -325 mesh. This testing confirmed problems identified in the limestone plant tests and highlighted these others:

a. Blowby during bag filling and blower choking was even more severe

b. The slide valve vent control design was not acceptable. During bag filling the open slide valve allowed excess product to vent from the bag, significantly increasing bag filling time. In addition, it was clearly evident that the highly abrasive silica dust would cause rapid wear and jamming of the slide valve.

These problems were addressed by:

a. Developing a new mechanical clamp to more effectively seal the bag valve/nozzle interface

b. Incorporating a pinch valve in the vent line to control vent flow

c. Replacing the blower with a separate air-powered eductor for each nozzle to supply the required vacuum and flow.

The final system design, incorporating these improvements, is described in detail in the next subsection.

2.2 FINAL SYSTEM DESIGN

The system designed and fabricated for the full field evaluations included the following major features:

a. Eccentric tubes to maximize venting area

b. Purge air tube in the bottom of the product fill tube to reduce product spillage

c. Vacuum supplied by eductors powered by a high pressure blower for bag venting

d. Pinch valve for vacuum and bag venting control

e. Electric/pneumatic control systems to cycle the nozzle vacuum and bag clamp systems

f. Improved bag clamp design to reduce product blowby during bag filling.

Details of the components of the system are described in the following subsections.

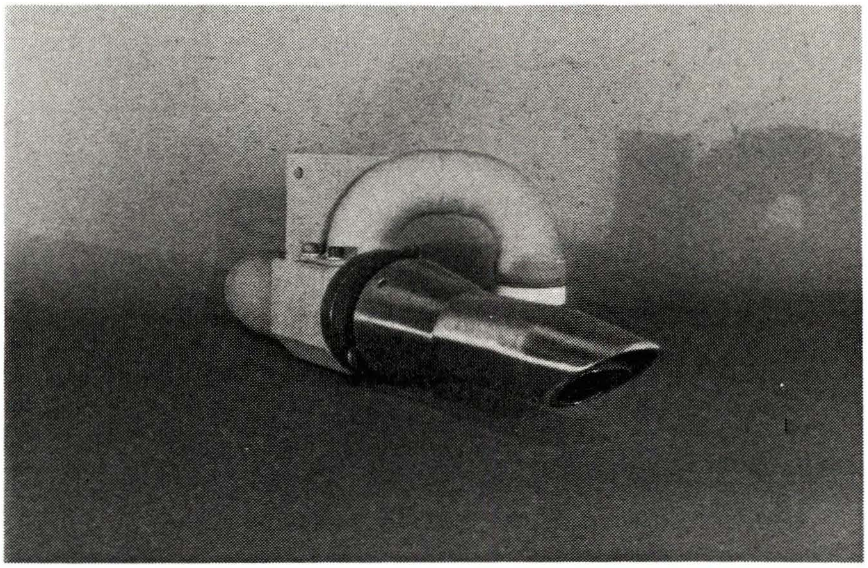
2.2.1 Nozzle Assembly

The nozzle assembly, shown in figure 14, includes two thin wall steel tubes with the 1-5/8 in OD inner tube mounted eccentrically in the bottom of the 2-in OD outer tube. Both tubes were hard chromed to protect against abrasive wear.

The inner tube, which is the product feed tube, had the discharge end curved downward to direct product flow towards the bottom of the bag. The leading end of the outer tube was tapered inward and cut on an angle so that it would insert into the bag valve more easily.

A small diameter, oval shaped tube was mounted in the bottom of the product fill tube to supply purge air. The purge air was intended to blow off product remaining in the fill tube to reduce spillage after bag ejection.

A tapered cone was added to the rear of the nozzle to make a tighter fit between the nozzle and the bag valve to further reduce blowby during filling.



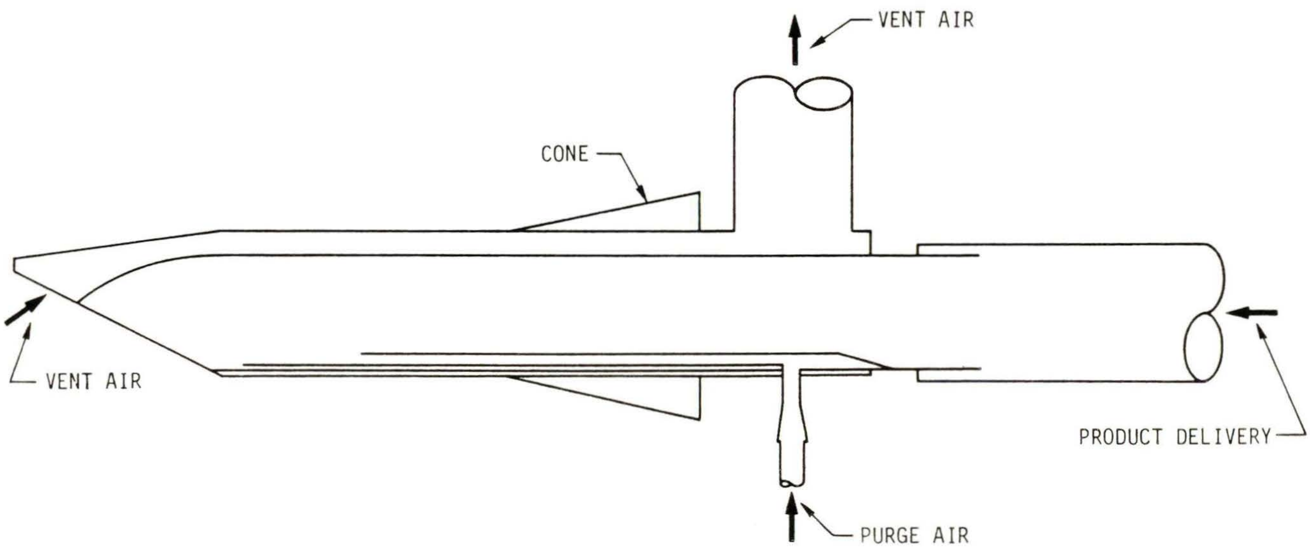


FIGURE 14. - Nozzle assembly.

2.2.2 Vacuum System Assembly

The vacuum system is illustrated in figure 15. Each nozzle vent is connected to a 1-1/2 in venturi eductor manufactured by Fox Valve Development Corp.* Each eductor is supplied with approximately 30 cfm of motive air at 7 psi using an MD Pneumatics Inc. Model 17/46 3210 industrial blower. Motive air is delivered to each eductor through a 3-in-diam, schedule 40 pipe manifold with 3/4 in distribution ports and flexible rubber hose.

The motive air supplied to each eductor induces 45 cfm of air from the open nozzle vent. With the vent line from the nozzle closed, the eductor develops up to 25 in Hg vacuum.

The pinch valve between the eductor and nozzle controls venting through the nozzle. While the bag is filling, the pinch valve is closed, preventing venting through the nozzle and causing the eductor to develop maximum suction. When the bag is full, the pinch valve opens, drawing excess air through the nozzle from the bag. After bag ejection, the pinch valve closes, readying the nozzle for placement of the next bag.

In the original system design, the pinch valve was a "Mini Flex" manufactured by Red Valve. It used a molded gum rubber sleeve with a maximum operating pressure of 50 psig. Stress cracks developed in the rubber sleeve leading to short life and requiring frequent replacement.

A heavier duty valve, style A, also manufactured by Red Valve, replaced the Mini Flex. This valve has a working pressure of 125 psig and uses a neoprene reinforced gum rubber sleeve.

The air and dust discharges from the eductor into a 2-in reinforced hose to the final discharge point.

2.2.3 Vacuum and Bag Clamp Control System

An electric/pneumatic control system automatically cycles the nozzle vacuum and bag clamp systems on each nozzle. This system is tied into the existing bagging machine pneumatic control system.

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*Reference to specific brands, equipment, or trade names in this report is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.

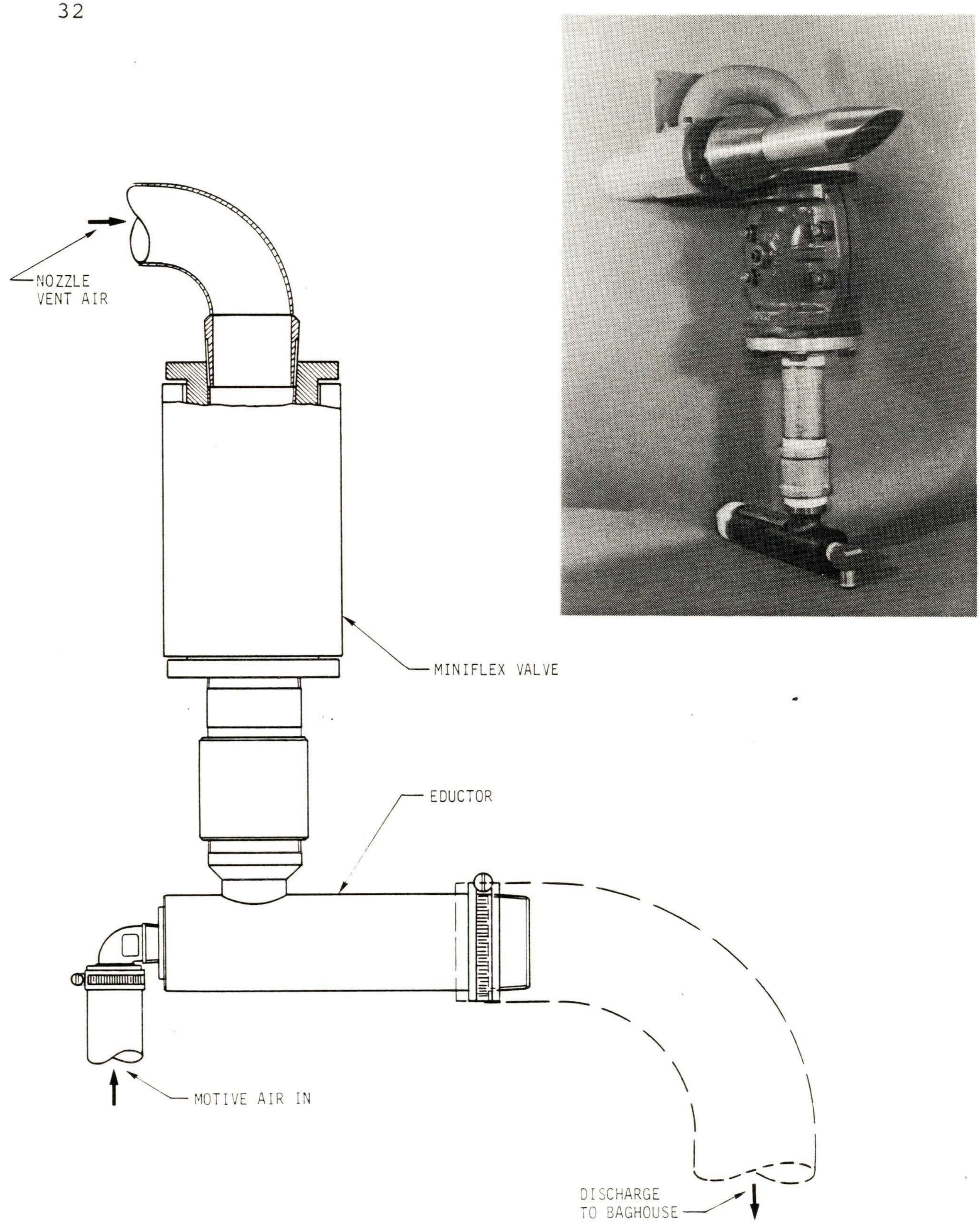


FIGURE 15. - Vacuum system assembly.

The system, shown schematically in figure 16, begins controlling the nozzle vacuum and bag clamp after the bag is filled to a preset weight. When the bag reaches weight, the counterweight system on the bagging machine triggers an air signal which pneumatically closes the product fill tube pinch valve. This same air signal triggers an electric/pneumatic pressure switch in the new control system starting the cycle.

Closure of the pressure switch activates a set of electrical timers designed to allow a preset time. Two timers are used to control:

a. Vacuum through the nozzle vent
b. Bag clamp opening.

The timer for the vacuum system opens and closes the vacuum pinch valve. When the timer is activated, it opens the pinch valve, pulling air through the nozzle vent. After a preset time, the timer recloses the pinch valve shutting off nozzle vacuum. The timer for the bag clamp delays bag clamp opening for a preset period of time.

Both timers are adjustable so that the sequence of operations can be optimized in the field. During the first field evaluation, for example, bag clamp opening was

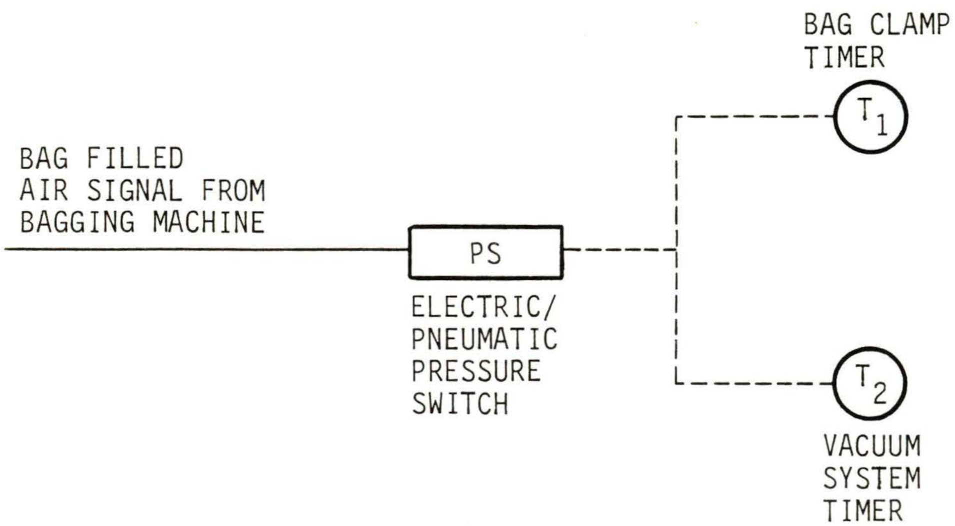


FIGURE 16. - Vacuum and bag clamp control system schematic.

delayed for 5 s. The vacuum pinch tube opened immediately after the bag reached weight and remained open for 8 s, venting the bag and cleaning the bag valve as the bag ejected from the nozzle. The pinch tube then closed, shutting off the nozzle vacuum for placement of the next bag.

When the operator pushes the start button to fill the next bag, the air pressure on the pressure switch is released allowing the switch to return to its normally open position. The timers are deenergized and reset, and the bag clamp closes until the cycle begins again when the new bag reaches weight.

The control system, was housed in two NEMA 12 enclosures as shown in figure 17.

2.2.4 Bag Clamp Assembly

Standard bag clamps apply force over only a small area to hold the bag on the nozzle during filling. The standard clamp does not seal the bag valve/nozzle interface and excessive blowby results.

The new bag clamps described in this section were designed to provide clamping force around a larger segment of the bag valve/nozzle interface circumference.

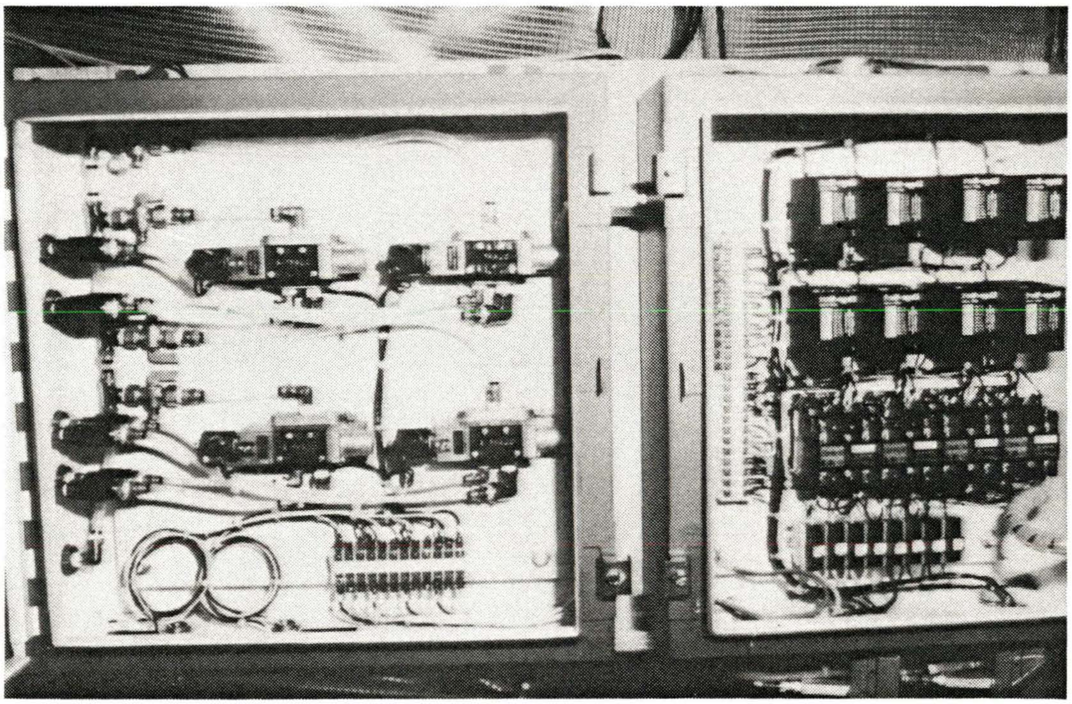


FIGURE 17. - Vacuum and bag clamp control system.

2.2.4.1 Dual Cylinder Bag Clamp Design

The bag clamp assembly, shown in figure 18, uses two-160° clamps activated by individual air cylinders mounted on either side of the nozzle. The clamp surfaces are pure gum rubber vulcanized to a steel backing plate.

The air cylinders are double acting Fabco pancake cylinders with a 1-5/8 in bore and a 1-1/2 in stroke. The cylinders provide a horizontal clamping force of 125 lb at 60 psig air pressure.

The clamp assembly is mounted on a U-shaped steel bracket bolted to the nozzle mounting block. Steel guides riding on teflon slides are used to ensure proper alignment of the clamp and nozzle.

Field modification of this design was required prior to the initial system test. The bottom of the bag clamp, with 320° of clamping, caused the bag to tear as it expanded during filling. To eliminate this problem, the metal backing plates were cut through, as shown in figure 19, allowing the bottom of the clamp to flex outward as the bag filled. This resulted in effective clamping over 240°.

While this clamp assembly did reduce product blowby during bag filling, there were several major problems with the design:

a. The clamping force was concentrated on the sides of the nozzle with very little clamping force downward at the top. As a result, the clamp tightly sealed the bag valve/nozzle interface along the sides but pinched the bag valve open along the top of the nozzle. While total blowby was less, it was concentrated along the top of the nozzle. This concentrated stream rebounded off the nozzle support increasing contamination of the operator and the bag surface.

b. The U-shaped clamp support bracket blocked the blowby and forced it to rebound onto the bag surface and toward the operator.

c. The clamp cylinders, mounted directly beside the nozzle, were heavily contaminated with the abrasive product. This caused the cylinders to bind, requiring frequent maintenance.

A second clamp assembly, described in the next subsection, was designed to overcome these problems.

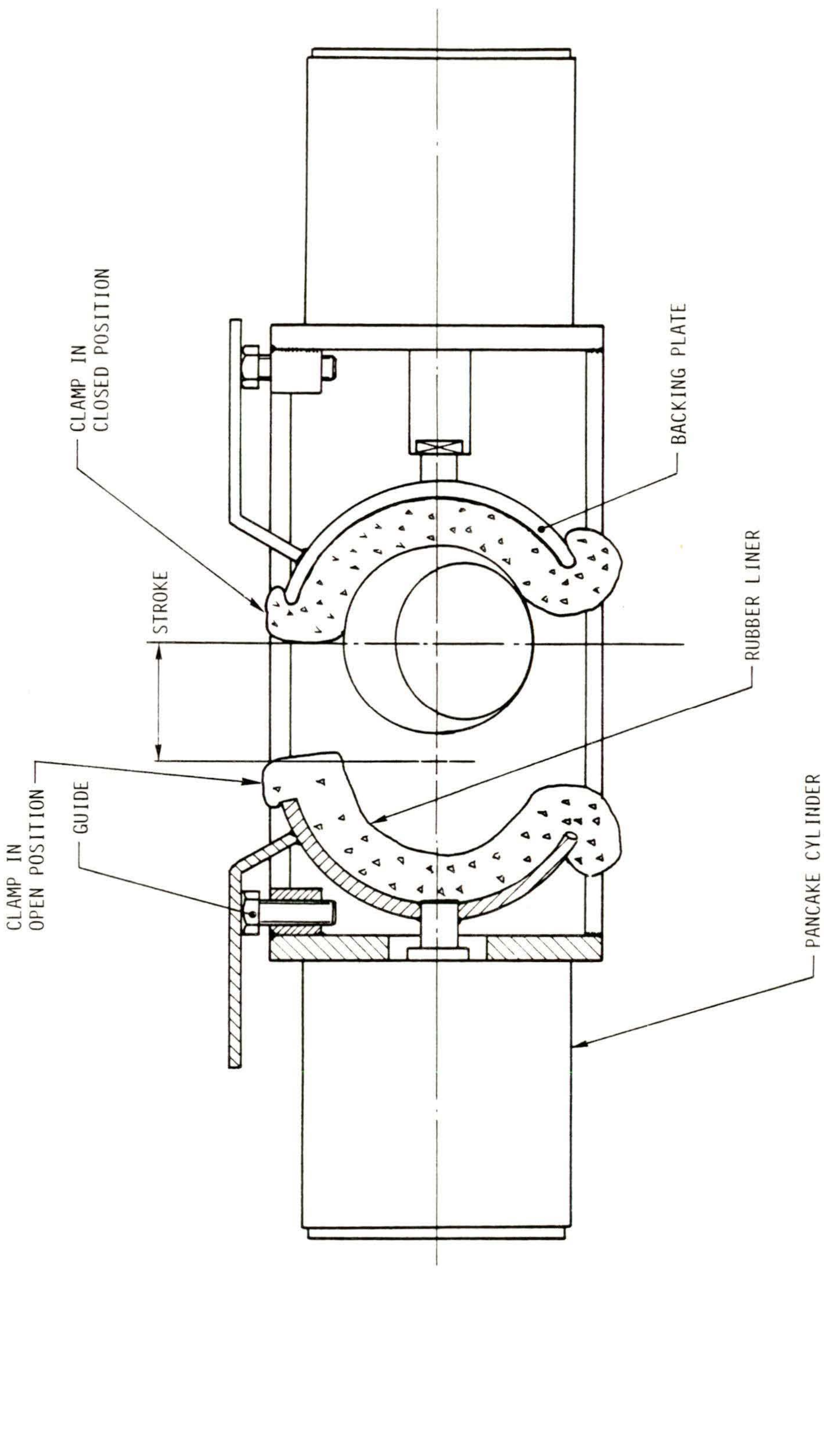


FIGURE 18. - Dual cylinder bag clamp

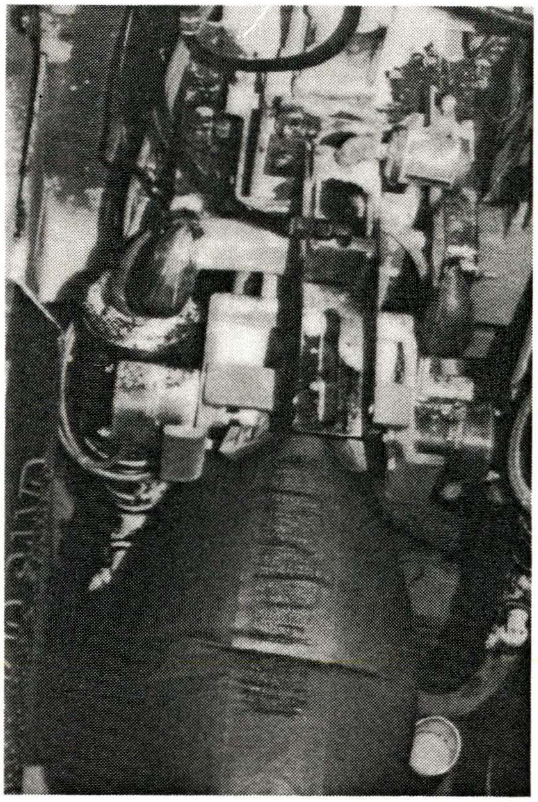


FIGURE 19. - Bag clamp assembly no. 1 with modified clamp.

2.2.4.2 Single Cylinder Bag Clamp Design

The second bag clamp assembly, shown in figure 20, uses a single 240^{o} clamp activated by one air cylinder mounted above the nozzle. Like the first assembly, the clamp surface is pure gum rubber vulcanized to a steel backing plate. The backing plate was split as shown allowing each half of the clamp to pivot around the nozzle.

The air cylinder is a double acting ARO Provenair II cylinder with a 1-1/2 in bore and a 2-in stroke. The cylinder provides a downward force of 105 lb at 60 psi air pressure. The cylinder is mounted on a steel support bracket centered over the nozzle.

When the clamp is pushed downward on the nozzle with a force of 105 lb, the sides of the clamp pivot around their axes, exerting a side force on the nozzle of 45 lb. When

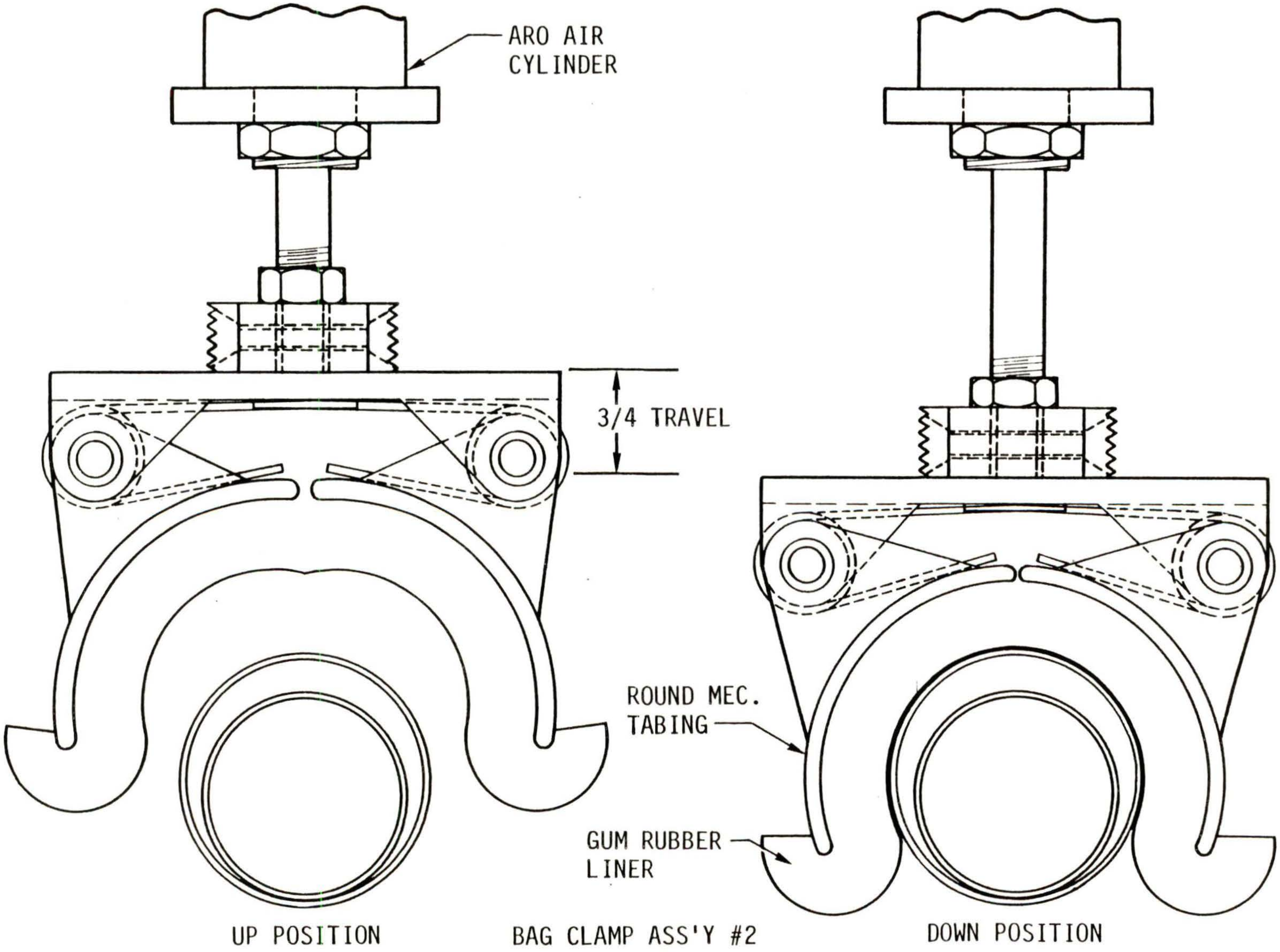


FIGURE 20. - Bay clamp assembly no. 2.

the air cylinder retracts, the sides of the clamp are pivoted outward by the torsion springs in each pivot assembly. This spreading outward when the clamp is retracted gives extra clearance around the nozzle for easier loading of the next bag.

The field evaluation of this single cylinder clamp is presented in detail in section 3 of this report.

3. FIELD EVALUATION OF THE NEW DUST CONTROL SYSTEM FOR BAGGING MACHINES

The initial evaluation of the new system was conducted during March 1983 in a mill bagging ground silica. The results of this initial test indicated that the system could achieve significant dust reduction but that the bag clamp design required improvement.

The system, with a redesigned bag clamp, was installed and tested during October 1983 in a second mill bagging ground silica.

Details of both field evaluations are described in the following sections.

3.1 FIELD EVALUATION - SITE A

The initial evaluation of the new system was on a four station, St. Regis 150-FC force flow packer with a fluidizing air pressure of 2 to 3 psig. The product was ground silica ranging from -120 to -325 mesh.

A plan view of the site is shown in figure 21. The bagging machine was located in an enclosed room on the second floor. A chain conveyor transferred the filled bags to a belt conveyor from which two men transferred them to pallets on the loading dock or directly onto flatbed trucks.

The bagging room was ventilated using an exhaust system intaking behind the bagging station. The exhaust air was ducted to a baghouse filtration unit on the third floor. Spilled product was recycled from a hopper under the bagging station using a bucket elevator. The elevator enclosure was also exhausted to the baghouse.

3.1.1 Test Methods - Site A

The evaluation took place over a 2-week period. During the first week, baseline dust levels and productivity were monitored with the mill's standard bagging system. Over the weekend, the new system was installed, requiring approximately 30 manhours. Dust levels and productivity were then monitored during the second week using the new system.

Dust levels were measured using both gravimetric samplers and instantaneous respirable dust monitors. Output from the instantaneous monitors was continuously recorded on a data logger and dual channel strip chart recorders.

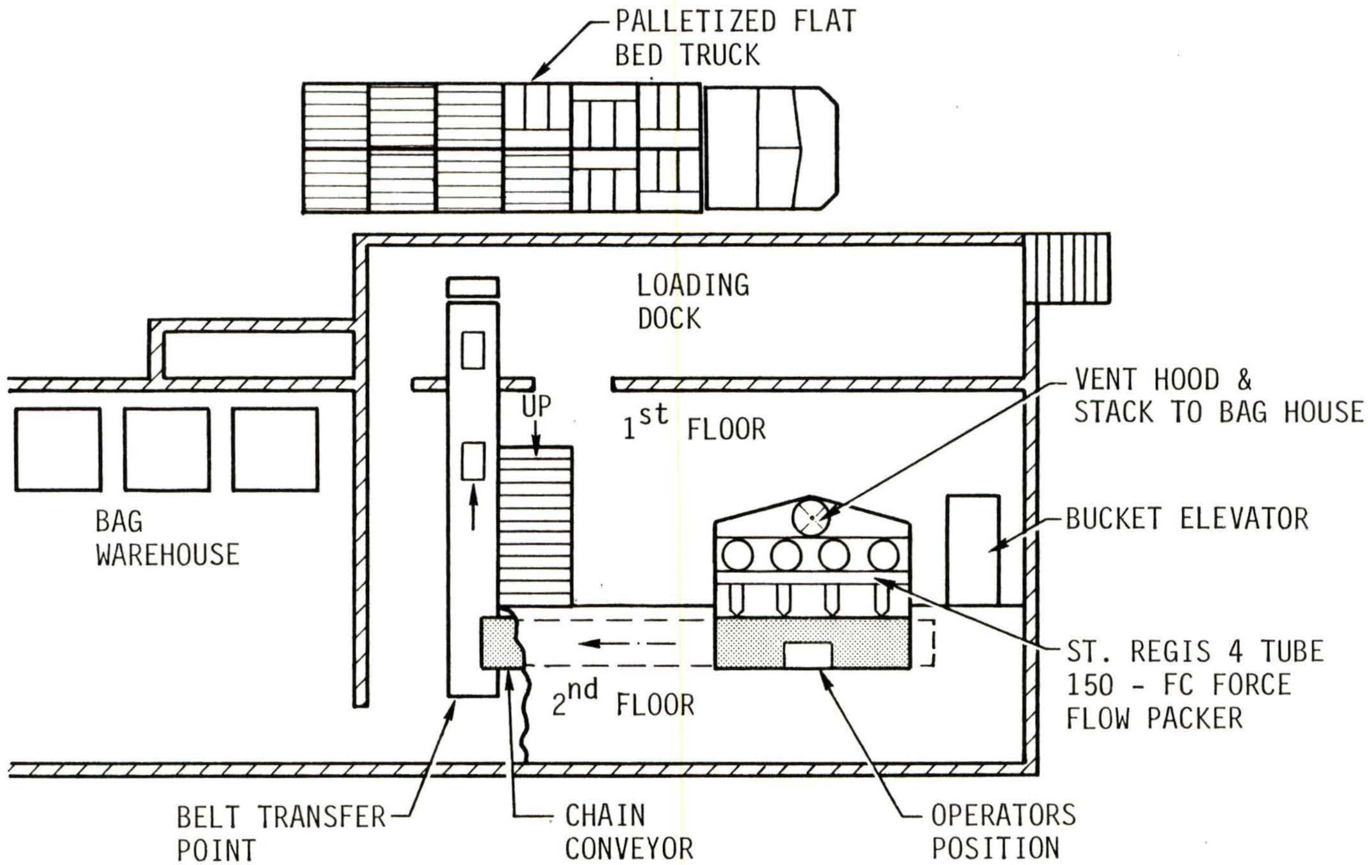


FIGURE 21. - Plan view - site A.

Sampling locations, shown in figure 22, are described below:

a. Bagging machine operator - A gravimetric sampler and the cyclone from an instantaneous monitor were pinned to the lapels of the operator to monitor the operator's respirable dust exposures. A package of four gravimetric samplers were also suspended in front of the operator to monitor his exposures.

b. Bagging room background - A package of four gravi- metric samplers and the cyclone from an instan- taneous monitor were mounted on the wall of the enclosure to monitor the background respirable dust levels inside the bagging room.

c. Bagging room intake - A cyclone from an instantaneous monitor was suspended in a window in the wall of the bagging room to monitor the respirable dust levels in the air being drawn into the bagging room from the conveyor and loading areas.

d. Chain conveyor to belt transfer point enclosure - A cyclone from an instantaneous monitor was suspended inside a brattice cloth enclosure erected over the transfer point to monitor the dust levels generated during conveying and transfer of the bags.

e. Bagging room exhaust duct - A cyclone from an instantaneous monitor was suspended inside the exhaust duct between the bagging room and baghouse to monitor the total respirable dust levels generated during bagging.

f. Stackers - Two gravimetric samplers were pinned to the lapels of each of the two men stacking bags on pallets at the loading dock to monitor their respirable dust exposures.

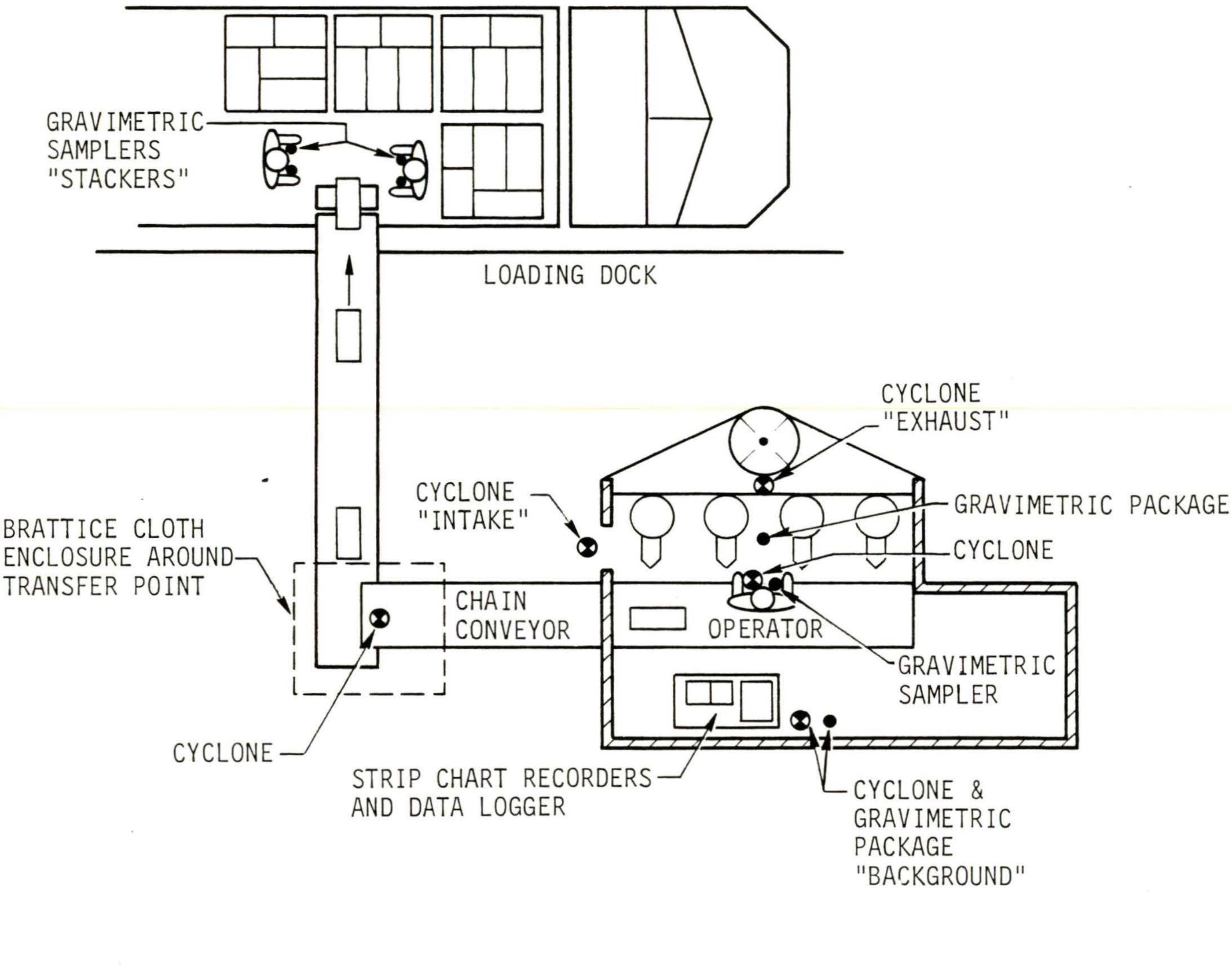


FIGURE 22. - Respirable dust sampling locations - site A.

During testing, routine activites and unusual occurrences, such as bag breakage, were monitored and noted on the strip chart recordings to be correlated with dust levels. The sampling periods were selected to coincide with the time required to load a truck, approximately 480 bags. Sampling was conducted during the loading of the four different products bagged at the plant:

a. -120 mesh

b. -180 mesh

c. -200 mesh

d. -325 mesh.

A different set of gravimetric samplers was used for each of the four products during each week of sampling.

Productivity was measured in two ways:

a. The time to fill individual bags

b. The time to fill a run of bags (25 to 50).

At the conclusion of the 2-week evaluation, the data were analyzed for each week and then compared. For each week's data (week 1 conventional system, week 2 new system), the following analyses were performed:

a. Gravimetric samples for each product type were weighed and dust concentrations in milligrams per cubic meter were calculated. Where more than one sampler was used at a sampling location, the results were averaged.

b. Data from the instantaneous monitors were used to calculate time weighted average (TWA) concentrations over the times required to load each truck. These TWAs for each product type were then combined and averaged for the week of sampling.

c. Productivity time study data were used to calculate the average time required to fill bags of each product type, the average times to fill 50 bags, and the time to load a 480-bag truck.

The results of the initial evaluation at site A are presented in the next section.

3.1.2 Test Results - Site A

The conventional system at site A, monitored during the first week, used a fluidizing pressure of 2 to 3 psig and operated as follows. At the start of bag filling, a pinch clamp on the product fill tube opened and a pneumatic cylinder rotated the nozzle upward, pressing it against a small pad to clamp the bag in place. Filled bag weight was controlled by a counterweight system. When the bag reached weight, the pinch tube closed and the nozzle was released and rotated downward allowing the bag to fall onto the chain conveyor.

During bag filling, the conventional system exhibited significant blowby of air and product between the bag valve and nozzle as shown in figure 23. As the filled bag was ejected from the nozzle, a rooster tail of product was blown from the open bag valve, as shown in figure 24. The severity of the blowby and rooster tail varied among product types. Conditions were least severe when bagging coarser product (-120 mesh), and became more severe with the finer products (-200 and -325 mesh).

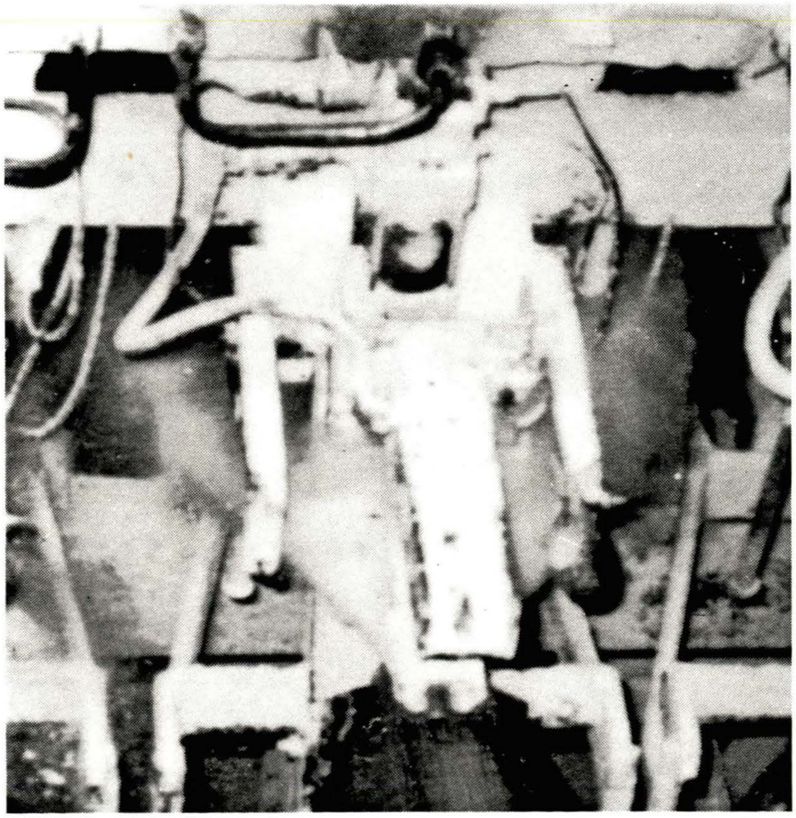


FIGURE 23. - Blowby during bag filling - conventional system at site A.

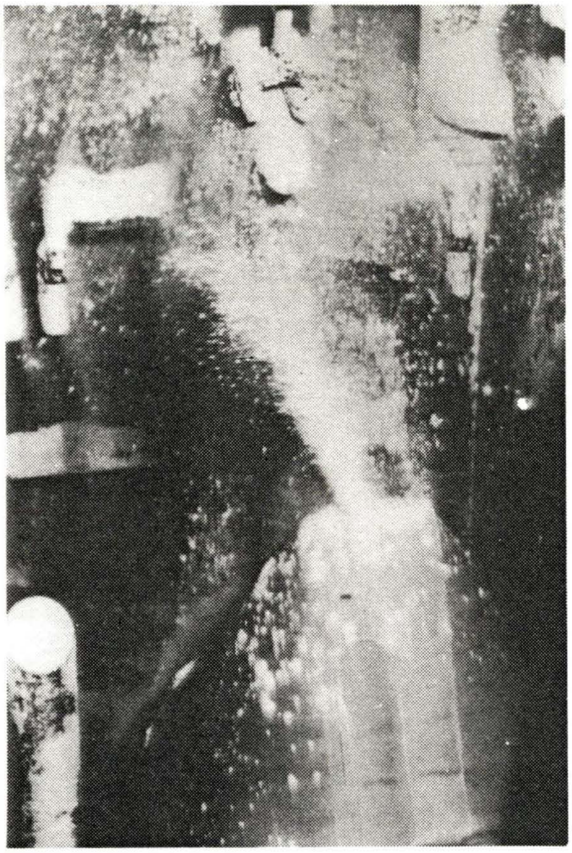


FIGURE 24. - Rooster tail after bag ejection - conventional system at site A.

The average respirable dust concentrations measured for each product type using the instantaneous samplers are shown in table 2.

The increase in blowby and product rooster tail with finer products is clearly shown by the concentrations in the exhaust duct. These measurements, which are representative of the total respirable dust released during bag filling and ejection, almost doubled with the -325 mesh product.

The levels in the bagging room intake and in the transfer point enclosure also increased with the finer products. These levels are an indicator of the amount of contamination on the outside of the bags and the degree of continued venting through the bag valve during conveying and handling.

In general, the bagging room background levels track those measured in the bagging room intake. This indicates that the exhaust ventilation system was effectively capturing dust from the bagging machine preventing further contamination of the bagging room environment.

TABLE 2. - Average respirable dust concentrations - conventional system

Location	Respirable dust concentrations, mg/m^3			
	Product			
	-120 mesh	-180 mesh	-200 mesh	-325 mesh
Bagging room exhaust duct	133.14	120.56	178.34	200.00*
Chain conveyor to belt transfer point enclosure	0.21	0.27	0.42	0.33
Bagging room intake	0.11	0.13	0.45	0.29
Bagging machine operator	0.27	0.49	1.13	0.42
Bagging room background	0.14	0.16	0.53	0.32

*Maximum concentration measurable with dust monitor.

Average levels at the operator, however, did not track the background levels in the bagging room. The exhaust system was less effective in controlling dust levels at the operator's position, much closer to the primary dust sources.

The new system, installed between weeks 1 and 2, incorporated the first bag clamp design described in section 2.2.4.1. The control system was adjusted so that the vacuum system pinch valve opened and the product fill tube closed immediately after the bag reach desired weight. Bag clamp opening was delayed for 5 s to relieve excess air before bag ejection. The vacuum line remained open for an additional 3 s after bag clamp release to clean the bag valve and reduce product spillage as the bag ejects. The vacuum pinch tube then closed, shutting off the nozzle vacuum for placement of the next bag. The exhaust from the nozzle vent system was ducted to the bucket elevator enclosure.

The new system dramatically reduced product blowby during bag filling, as shown in figure 25, and virtually eliminated the rooster tail from the open bag valve after bag ejection, as shown in figure 26. These improvements are reflected in the reduced average respirable dust concentration measured using the instantaneous samplers shown in table 3 for each product type.

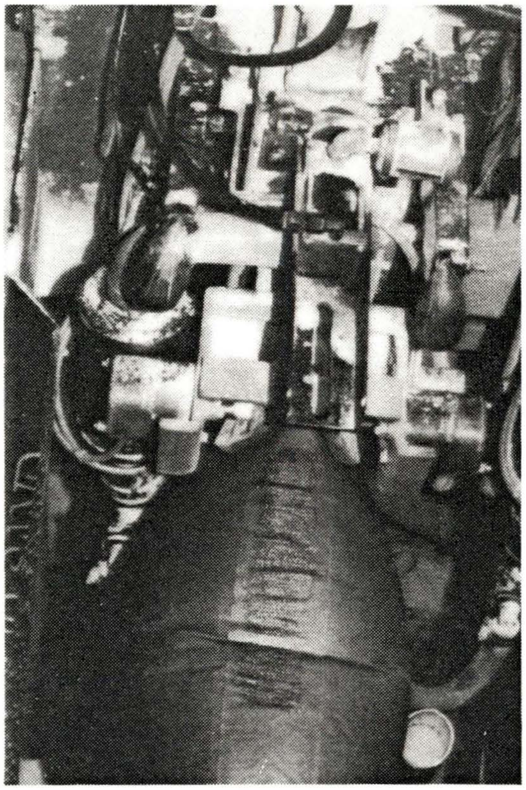


FIGURE 25. - Blowby during bag filling - new system at site A.

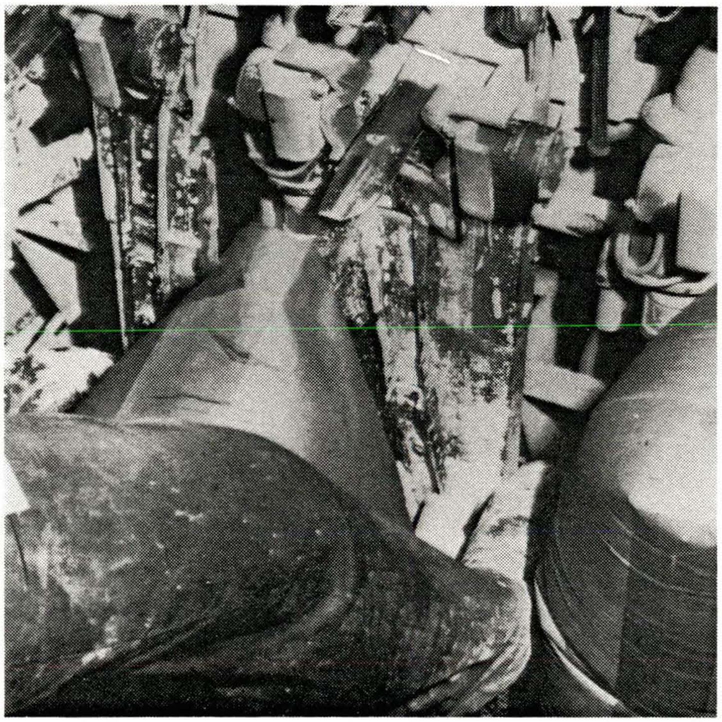


FIGURE 26. - Rooster tail eliminated after bag ejection - new system at site A.

TABLE 3. - Site A - average respirable dust concentrations - new system

Location	Respirable dust concentrations, mg/m^3			
	Product			
	-120 mesh	-180 mesh	-200 mesh	-325 mesh
Bagging room exhaust duct	10.95	22.27	18.38	21.87
Chain conveyor to belt transfer point enclosure	0.15	0.12	0.23	0.13
Bagging room intake	0.08	0.07	0.11	0.06
Bagging machine operator	0.14	0.09	0.35	0.07
Bagging room background	0.14	0.07	0.27	0.07

The reduced dust levels achieved with the new system are summarized in table 4. The effectiveness of the system in reducing blowby and the rooster tail is clearly shown by the reduction in average dust levels measured in the exhaust stack. For the new system, these levels were 83 to 92% less than those for the conventional system.

Significant reductions were also achieved at the operator's position. For the -325 mesh product, for example, the new system achieved an 83% reduction in average respirable dust levels. The effectiveness of the system is also shown in figure 27, which compares strip chart recordings of the instantaneous dust levels measured at the operator for the old and new systems bagging -325 mesh product. As shown, the levels recorded for the new system are much lower and much less variable than those for the conventional system. The levels for the new system are actually lower than the established threshold limit value (TLV) which is approximately 0.2 mg/m^3 and are essentially the same as those measured at the bagging room background location. Results measured with the gravimetric samplers confirmed the instantaneous respirable dust data.

TABLE 4. - Site A - percent reductions in average respirable dust concentration

Location	% reduction			
	Product			
	-120 mesh	-180 mesh	-200 mesh	-325 mesh
Bagging room exhaust duct	92	83	90	89
Chain conveyor to belt transfer point enclosure	29	56	45	61
Bagging room intake	27	46	76	79
Bagging machine operator	48	81	69	83
Bagging room background	-	56	49	78

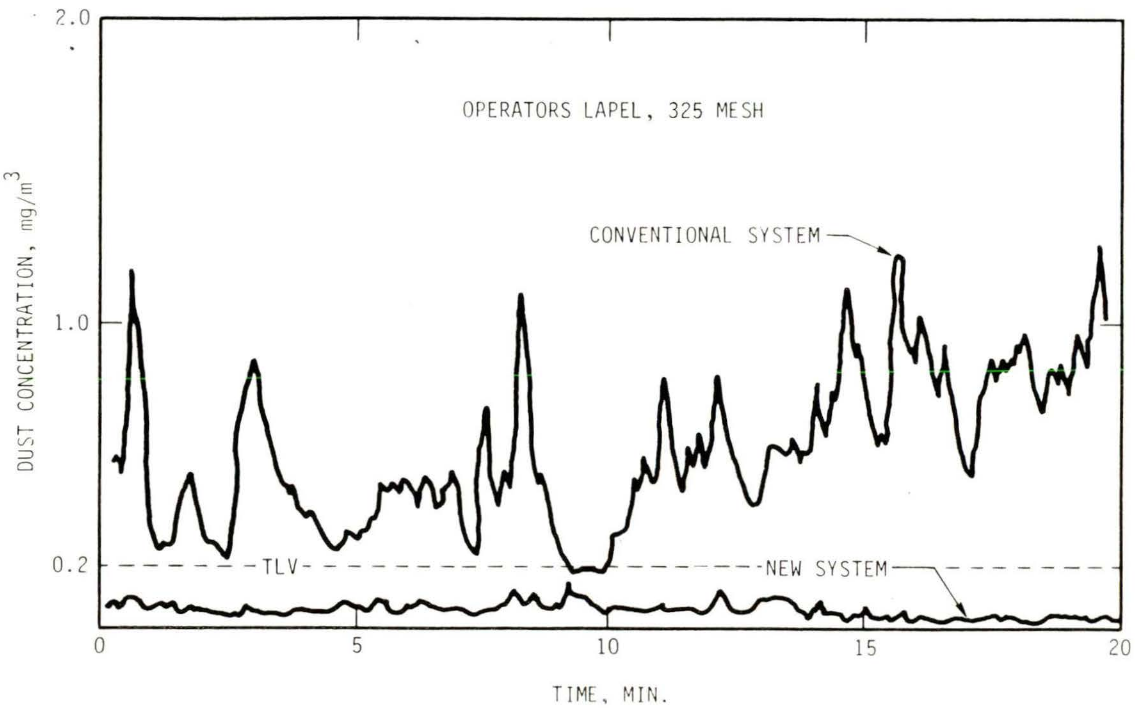


FIGURE 27. - Strip chart recording of instantaneous dust levels for the conventional and new system - site A.

The reductions achieved in dust released from the bag surface during bag transport, while significant, were not as high as those near the filling operation. Reductions measured in the chain conveyor to belt transfer enclosure, e.g., ranged from 29% for the -120 mesh product to a high of 61% for the -325 mesh material. The new system was less effective in controlling product contamination of the bag surface than it was in reducing dust discharge into the airstream for two reasons:

a. The purge tube was not effective in controlling product spillage after bag ejection. A small amount of product still dropped from the product fill tube onto the bag surface after bag ejection.

b. Product blowby during bag filling cannot be totally eliminated. Excess pressure must be relieved to prevent bag breakage and increased fill times. While the clamp design used in site A significantly reduced blowby, the U-shaped support bracket caused the blowby that did occur to rebound onto the bag surface.

The bag surface contamination from spillage and blowby was released into the air during bag transport and handling.

The time study data showed that the new system did not affect the actual time required to fill a bag with product. The new system, however, did reduce the production rate due to the time required to exhaust the excess air from the bag before ejection. The average times required to fill 50- to 100-lb bags with each system are compared in table 5 for each product type.

TABLE 5. - Bag loading times for conventional and new system - site A

Product	Time to load fifty 100-lb bags		Load time increase with with new system		
	Conventional system	New system	Per bag	Per 50 bags	Per truck
-120 mesh	3 min 29 s	4 min 39 s	1.4 s	1 min 10 s	11 min 12 s
-180 mesh	3 min 39 s	5 min 2 s	1.7 s	1 min 23 s	13 min 16 s
-200 mesh	4 min 10 s				
-325 mesh	5 min 50 s	7 min 6 s	1.5 s	1 min 16 s	12 min 9 s
		Average	1.5 s	1 min 16 s	12 min 12 s

The increased time results from the delay introduced when the operator loads nozzle 1 after finishing nozzle 4. With the conventional system, the bag on nozzle 1 is filled and ejected before the operator finishes loading nozzles 2, 3, and 4. With the new system, the filled bag is exhausted for 5 s before ejection. As a result, during each four-bag cycle, the operator had to wait at No. 1 nozzle until the bag ejected. This delay translated into the loading time increase shown in table 5. These time increases had no significant impact on the mill's total productivity.

The new system at site A achieved significant dust reductions with no significant impact on the mill's total productivity. The evaluation, however, did identify several aspects of the design needing additional improvement:

a. The purge tube did not stop product spillage from the fill tube after bag ejection

b. The clamp support bracket caused product blowby to rebound onto the bag surface during bag filling

c. The clamp cylinders, which were mounted directly beside the nozzle, were heavily contaminated with the abrasive product causing the rods to bind.

The bag clamp was redesigned to correct the clamp related problems. It was installed and tested as part of a new system in another mill bagging silica flour. Results are presented in the following subsection.

3.2 FIELD EVALUATION - SITE B

The second evaluation of the new system, with a redesigned bag clamp, was conducted during October 1983 in another mill bagging ground silica. The 395 grade product, which is equivalent to -325 mesh, was bagged using a four station St. Regis 714-UC-4 force flow packer with a fluidizing air pressure of approximately 4 psig. Product was bagged in both 50-lb and 100-lb bags, approximately equally. Only 3 of the 4 stations were used during the evaluation.

Plan views of the site are shown in figure 28. The bagging machine (packer 1) was located on the second floor between two other machines (packer 5 and packer 2). A spring conveyor transferred the filled bags to a belt conveyor on the first floor. Two men transferred the bags from the belt conveyor to pallets on open flat bed trucks, or into enclosed trucks or railcars.

The bagging area was ventilated using an exhaust ventilation system intaking behind each bagging station. The exhaust air was ducted to a baghouse filtration unit on the third floor. The bucket elevator enclosures were also exhausted to the baghouse.

3.2.1 Test Methods - Site B

The evaluation at site B also took place over a 2-week period. During the first week baseline dust levels and productivity were measured with the mill's standard bagging system. Over the weekend the new system was installed, requiring approximately 24 manhours. Dust levels and productivity using the new system were monitored during the second week.

To minimize contamination from the two adjacent bagging machines, packer 1 was enclosed using brattice cloth. A centrifugal blower was used to control airflow through the enclosure.

Dust levels at site B were measured using instantaneous respirable dust monitors with the outputs continuously recorded on a data logger and dual channel strip chart recorders. The sampling locations are shown in Figure 28 and described below:

a. Bagging machine operator - A cyclone from an instantaneous monitor was pinned to the lapel of the operator to monitor his respirable dust exposures

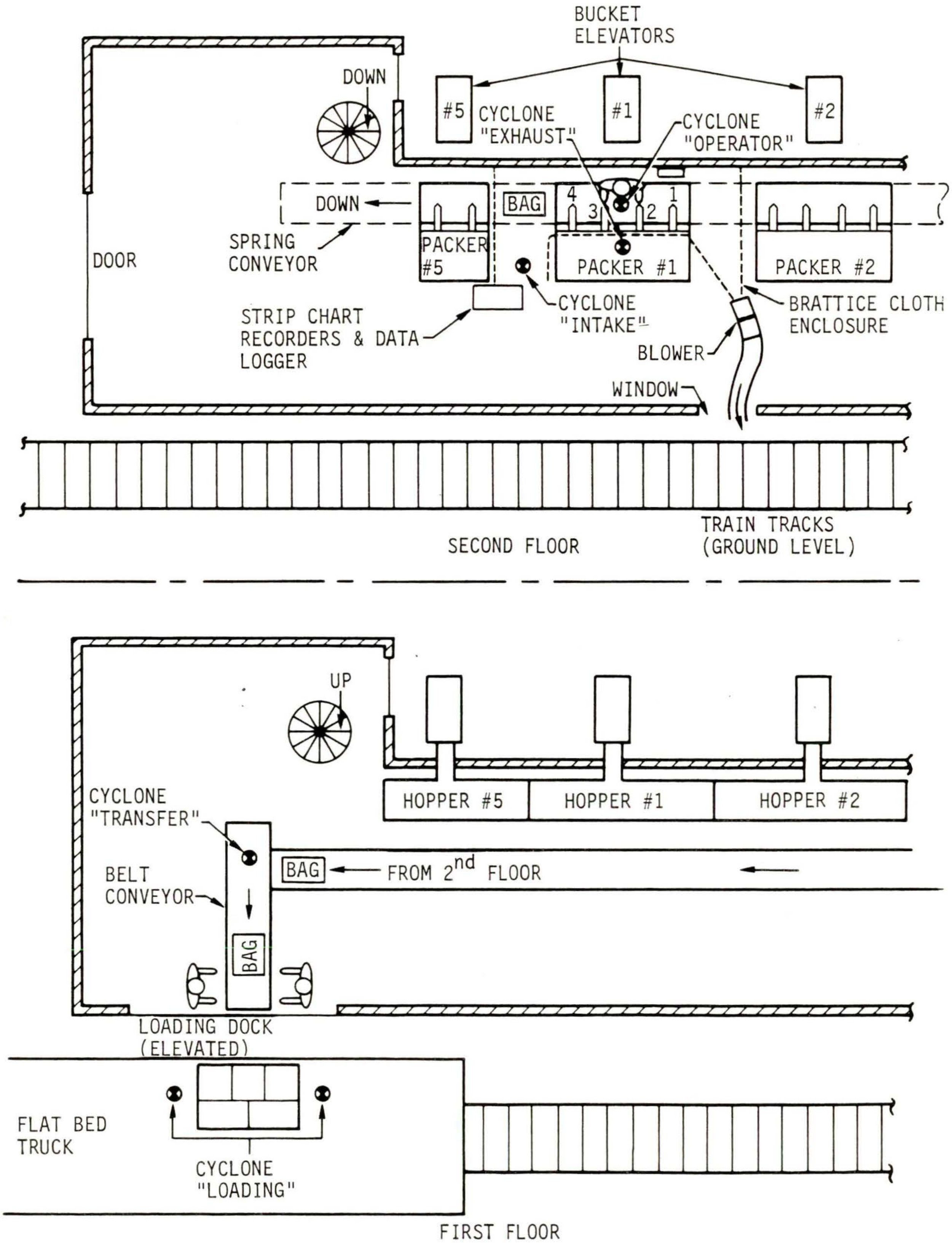


FIGURE 28. - Plan view - site B.

b. Bagging machine enclosure intake - A cyclone from an instantaneous monitor was suspended in the opening to the bagging room enclosure to monitor dust levels in the air being drawn into the enclosure

c. Exhaust duct - A cyclone from an instantaneous monitor was suspended in the exhaust between packer 1 and the baghouse to monitor total respirable dust generated during bagging

d. Conveyor to conveyor transfer point - A cyclone from an instantaneous monitor was suspended over the transfer point inside the mill's transfer point enclosure to measure dust levels generated during conveying and loading

e. Loading area - Cyclones from two instantaneous monitors were located adjacent to the stackers to monitor respirable dust levels while the bags were stacked on pallets. When loading onto flat bed trucks, the monitors were mounted on tripods on each side of the pallet. When loading into enclosed trucks and railcars, the monitors were mounted on each side of the belt conveyor.

During each week, sampling was broken into segments representing the time required to load a truck or railcar. Sampling was conducted while loading both 50-lb and 100-lb bags.

Productivity was monitored by measuring the time required to fill individual bags and the time required to fill a run of 25 to 50 bags.

At the conclusion of the 2-week evaluation, the data for each week were analyzed and compared. Data from periods of bagging 50-lb bags, and periods of bagging 100-lb bags were treated separately.

The results of the evaluation at site B are presented in the next section.

3.2.2 Test Results - Site B

The conventional system at site B, monitored during the first week, used a fluidizing pressure of approximately 4 psig. At the start of bag filling, a pinch clamp on the product fill tube opened. A pneumatic cylinder simultaneously pushed the bag clamp pad downward against the top of the nozzle to hold the bag in place. Filled bag weight was controlled by a counter weight system. When the bag reached weight, the pinch tube closed and the bag clamp retracted. Unlike the site A operation, the filled bag did not automatically eject from the nozzle. The operator pulled each bag from the nozzle, allowing it to fall onto the conveyor.

During bag filling, the conventional system exhibited much less blowby between the bag valve and nozzle than was seen at site A. The rooster tail from the bag valve after bag ejection was also much less severe. There are several possible reasons for these differences:

a. The bags used at site B were larger than those used at site A

b. The bags were not ejected immediately which allowed excess air to vent

c. The bags were supplied with polyethylene sleeve type valves which may have sealed more quickly and more tightly than the paper valves supplied in the bags used at site A.

The average respirable dust concentrations measured while filling both 50-lb and 100-lb bags during the week 1 conventional system evaluation are shown in table 6.

The less evident blowby and rooster tail at site B is confirmed by the average dust levels measured in the bagging station exhaust duct. The levels at site B are almost 80% less than those measured with an equivalent product at site A.

Dust levels measured at the operator were significantly higher than those measured in the bagging station enclosure intake. Product blowby and rooster tail, while less apparent visually than at site A, were still significant contributors to operator exposure at site B.

Dust levels at the conveyor transfer point were significantly higher than those measured at site A with an equivalent product. The most likely reason for this difference is the drop height between conveyors. The drop height at site B was significantly higher than at site A.

The bag loading area had not been monitored thoroughly at site A. The loading process at site B was monitored to determine the dust reduction capabilities with the new system.

TABLE 6. - Site B average respirable dust concentrations - conventional system

Location	Respirable dust concentrations, mg/m^3	
	100 lb bags	50 lb bags
• Bagging station exhaust duct	40.16	41.37
• Conveyor to conveyer transfer point enclosure	2.44	2.50
• Bagging station enclosure intake	0.19	0.24
• Bagging machine operator	0.98	0.92
• Loading area	12.51	5.44

As seen in table 5, the average dust levels measured at the bag loading area were extremely high with the conventional system. These high levels result from contamination on the surface of the bags and from venting from the bag valve. Inadequate ventilation in the enclosed trucks and railcars during bag palletizing compounds the problem.

The new bag filling system, installed between weeks 1 and 2, incorporated the improved bag clamp design described in section 2.4.2. The control system was adjusted so that the vacuum system pinch valve opened immediately after the bag reached weight and the product fill tube closed. Bag clamp opening was delayed 4 s to relieve excess air before bag ejection. The vacuum line remained open for an additional 2 s after bag clamp release to clean the bag valve as the operator pulled the bag from the nozzle. The vacuum pinch tube then closed, shutting off the nozzle vacuum in preparation for placement of the next bag. The exhaust from the nozzle vent system was ducted to the no. 1 bucket elevator enclosure.

The purge tube used in the site B system was modified from that used in site A. At site B, the purge was timed to start when the bag reached desired weight and stop when the bag clamp opened. The purge air volume was also significantly increased. It was theorized that a short, high intensity blast of purge air immediately before bag ejection would blow the product from the end of the fill nozzle into the bag and reduce product spillage. During bag filling, however, the purge tube filled with product, making the system inoperable. The purge tube concept has therefore been abandoned.

Testing of the system as described without a purge cycle was conducted during the second week. The average dust concentrations measured using the new system are shown in table 7.

TABLE 7. - Site B - average respirable dust concentrations - new system

Location	Respirable dust concentrations, mg/m^3	
	100 lb bags	50 lb bags
• Bagging station exhaust duct	35.72	23.72
• Conveyor to conveyer transfer point enclosure	0.38	0.56
• Bagging station enclosure intake	0.12	0.21
• Bagging machine operator	0.35	0.37
• Loading area	1.27	2.36

The dust level reductions achieved with the new system are summarized in table 8. There was over a 77% reduction for 50-lb bags and over an 84% reduction for 100-lb bags at the conveyor to conveyor transfer. A 90% reduction was achieved during loading of 100-lb bags into enclosed trucks at the bag handlers' locations.

The respirable dust reductions were lower at the operator's location than might be expected based upon the results achieved at site A. This is due, in part, to the fact that the blowby and rooster tail with the conventional system was a less severe problem to begin with at site B. It is also due to the influence of the dust in the intake airstream on the dust levels at the bagging station. With the new system operating, over one-third of the exposure of the bagging machine operation is due to intake air contamination. A significant amount of this intake contamination was due to other sources in the plant which were not controllable during the evaluation.

To determine the effectiveness of the new system in reducing operator exposure due to dust generated by only the bagging machine, the intake levels were subtracted from the levels measured at the operator. This analysis showed a 71 to 76% improvement for the new system which approaches that achieved while bagging comparable product at site A.

The time study data showed that the new system did not adversely affect bag filling time, but rather improved the production rate slightly. With the new system, approximately 20 s less total time was required to load

TABLE 8. - Site B - percent reduction in average respirable dust concentrations

Location	% Reduction 100 lb bags %	 50 lb bags %
• Bagging station exhaust duct	11.1	42.7
• Conveyor to conveyer transfer point enclosure	84.4	77.6
• Bagging station enclosure intake	36.8	12.5
• Bagging machine operator	64.3	59.8
• Loading area	89.8	56.6

fifty 50-lb bags, and 1 min 52 s less total time to load fifty 100-lb bags. This slight improvement in the production rate is likely due to fluctuation in the mill's fluidizing air pressure which directly imparts bag fill times.

The new system at site B achieved significant dust reductions without adverse impact on the mill's productivity.

The new clamp design offered improved performance with significantly less maintenance than the design tested at site A.

The new purge tube design proved ineffective in stopping spillage from the fill tube after bag ejection. It became inoperable due to plugging after a short period of operation and the concept of a pulsed purge has been abandoned. While spillage continues to be a problem, its impact on total system performance is not felt to be critical.

4. BAG VALVE EVALUATION AND DESIGN

The new bagging machine dust control system successfully addressed the bag filling activity, which is generally accepted as the dustiest portion of the bagging operation. The next most serious contributor to the respirable dust problem at bagging plants is believed to be bag valve leakage.

The bag valve most commonly used by the minerals processing industry is a simple, inexpensive sleeve created by folds of paper as shown in figure 29. The valve is opened (fig. 29) by pressing the sides of the bag valve creating an approximately square opening. When the bag is full, and falls onto the conveyor, the product inside the bag presses the valve flat as shown in figure 29. The contact between the flap and the bag top provides the seal.

This seal is not totally effective, especially if product is trapped between the flap and the bag top during filling and ejection. There is a tendency for these valves to leak as the bags are handled on conveyors, pallets, trucks, and railcars. Each time the bags are handled the valves spill product onto the outside of the bags and onto loading docks, pallets, trucks and railcar floors.

To address this problem, a bag valve evaluation was undertaken with two primary objectives:

a. To comparatively evaluate the performance of bag valves under actual operating conditions to determine if any commercially available bag valve designs are superior to others

b. To design a new bag valve which would provide a more positive seal.

4.1 COMMERCIALLY AVAILABLE BAG VALVE EVALUATION

Five commercially available valves were tested to determine if the performance of any was superior to that of the others. Valves tested included:

a. Standard paper valve

b. Polyethylene sleeve type valve

c. Extended polyethylene sleeve type valve

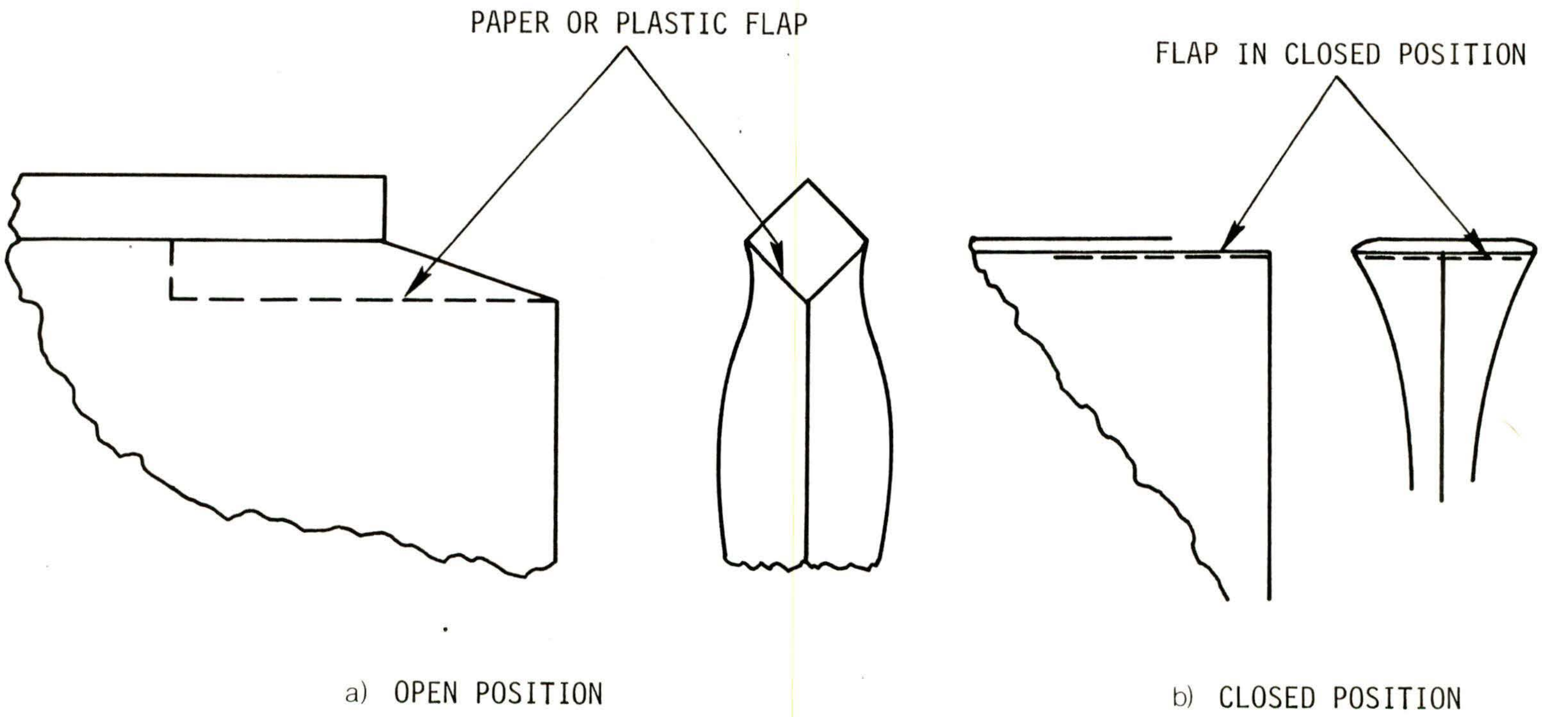


FIGURE 29. - Typical valve used in industry.

d. Double trap paper valve

e. Foam lined valve.

The valve evaluation was conducted at site A, the same mill where the new nozzle system was initially evaluated. Before the evaluation, the new top mounted bag clamp assembly was installed to reduce bag surface contamination from product blowby.

4.1.1 Test Methods

The evaluation spanned three weeks during August 1984. Prior to testing, a brattice cloth enclosure was erected around the conveyor and pallet loading area. A fan was used to blow 1,300 cfm of air through the enclosure. The enclosure and fan provided a controlled atmosphere and reduced contamination from sources other than bag valve leakage and bag surface contamination.

Dust levels were measured using instantaneous respirable dust monitors whose outputs were continuously recorded on a data logger and dual channel strip chart recorders. The sampling locations are shown in figure 30 and described below:

a. Bagging machine operator - A cyclone from an instantaneous monitor was suspended in front of the operator to monitor his respirable dust exposure.

b. Conveyor enclosure intake - A cyclone from an instantaneous monitor was suspended in the fan intake to monitor dust levels in the air being drawn into the enclosure.

c. Conveyor transfer - A cyclone from an instantaneous monitor was suspended over the conveyor downstream from the transfer point to measure dust generated during bag transfer between conveyors.

d. Loading area - Cyclones from instantaneous monitors were mounted near each stacker to monitor their respirable dust exposures.

During sampling, routine activities and unusual occurrences were monitored and recorded to be correlated with the dust data. Sampling periods were selected to span the time required to load a truck, approximately 480 bags. During a sampling period, only one valve type was used. During the 3-week evaluation each valve type

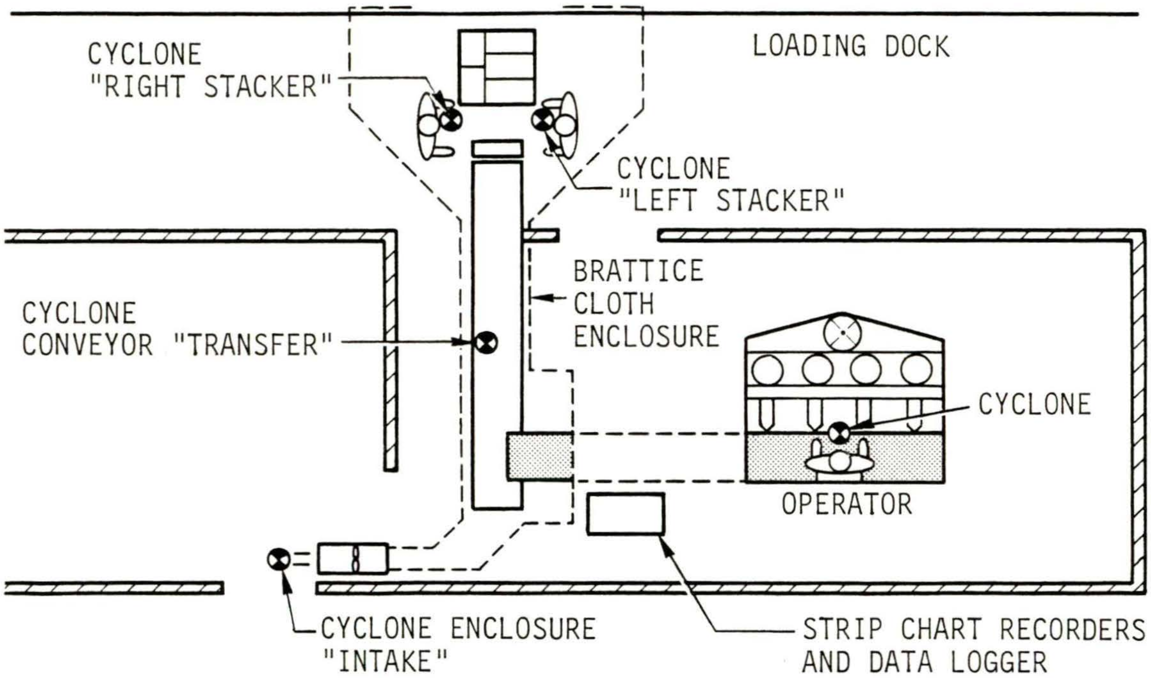


FIGURE 30. - Respirable dust sampling locations for the bag valve evaluation.

was tested while loading the different products bagged at the plant. Dust levels were also monitored before and after each sampling period to determine background concentrations at each sampling location.

At the conclusion of the evaluation, the data were analyzed for each valve type and then compared. The results of the evaluation are presented in the next section.

4.1.2 Test Results

During the 3-week evaluation period, testing of the five-bag valve types was conducted for three products (-325, -200, and -180 mesh). Due to low production during the period, only the testing while bagging -325 mesh product yielded sufficient data for valid valve performance comparison.

The average respirable dust concentrations measured while bagging -325 mesh product are presented in table 9. Note that testing of the foam lined valve was limited to one sampling period. The bag valves used with the foam liner were not sized properly to account for the added foam lining. The undersized valve made it difficult for

TABLE 9. Average respirable dust levels measured during bagging of -325 mesh product

Valve type	Average respirable dust levels, mg/m^3 [1]			
	Operator	Transfer	Left stacker	Right stacker
Standard paper (3) [2]	0.05	0.41	0.42	0.67
			Average 0.55	
Polyethylene sleeve (2)	0.24	0.47	0.35	0.56
			Average 0.46	
Extended polyethylene sleeve (2)	0.04	0.15	0.29	0.34
			Average 0.32	
Double trap paper (2)	0.20	0.67	0.72	0.79
			Average 0.76	
Foam lined (1)	0.02	0.25	0.41	0.70
			Average 0.56	

[1]Background dust levels subtracted.
[2]Number of sampling periods.

the operator to push the bag onto the nozzle and prevented the filled bag from automatically ejecting from the nozzle after bag clamp release. These problems created production delays and prevented additional testing of the foam valve.

The data shows apparent differences in dust control performance between the five valves at different sampling locations. Both the polyethylene sleeve type and the double trap paper type valves showed significant increases in dust levels at the operator. These increased levels at the operator are suspected to be due to more severe blowby during filling. These two valve types are significantly shorter than the standard paper valve, resulting in less sealing area around the nozzle.

The double trap valve also showed significant increases at both the transfer point and at the stackers. The polyethylene sleeve valve, on the other hand, showed a slight increase at the transfer point and a slight decrease at the stackers. This slight decrease by the time the bag reaches the stackers may indicate that the more flexible polyethylene sleeve achieves a tighter seal once closed than the more rigid paper valves.

The extended polyethylene sleeve valve showed comparably low levels at the operator. Its longer length provides better sealing around the nozzle reducing blowby. During transport and handling, the extended polyethylene sleeve valve appears to be clearly superior. Dust levels downstream from the transfer point were lower than those measured with the standard paper valve. At the stackers, dust levels were also lower. The longer length and flexibility of this valve apparently allows the valve to seal quickly and effectively.

Both the extended polyethylene and the foam valve indicated the potential for improved performance over the standard paper valve. A more thorough test of these three valves is going to be performed by the Bureau.

4.2 NOVEL BAG VALVE DESIGN

Currently used valve-type bags rely on the force of the material inside the bag to seal the filling valve. These valves, however, are not totally effective in preventing leakage. The objective of this effort was to design a new bag valve which would provide a more positive seal.

4.2.1 New Valve Concepts

Many mechanical and thermal sealing systems were reviewed early in the design effort. Some of the concepts given consideration included:

a. Hot melt sealing

b. Velcro strip seals

c. Zip lock strip seals

d. Mechanical wire spring seals

e. Semiautomatic twist lock seals

f. Foam seals.

Each of these concepts was burdened by costs that are high compared to the standard industry valve. The sealing ability of the hot melt, velcro, and foam seal concept were adversely affected by dust contamination. These drawbacks made the listed concepts impractical and they were dropped from further consideration.

The design effort then focused on valve designs that employed materials that are the same as, or similar to, those currently used in the mass production of bags. Several new bag valve configurations were designed, modelled, and tested with a nozzle to observe sealing action of the valve as the nozzle was withdrawn. These included:

a. Tube valve with plastic tab

b. Tube valve with wire loop

c. Composite tube valve with center crease

d. Composite tube valve with plastic tab

e. Tube valve with center and end crease

f. Composite tube valve with curl

g. Paper tube valve with plastic spring tab

h. Composite valve (paper/rubber) with plastic guide.

Each of these designs is illustrated and described in figures 31 through 38.

All valve concepts presented use the basic tube forming method of fabrication illustrated in figure 39. The paper is conventional bag stock and the plastic is a 10-mil thick polyethylene film. The adhesive is a hot melt.

Each design allows easy insertion of the nozzle. They are all designed to provide a spring back function to the tube so that it will return to a closed position after the nozzle is withdrawn, requiring no pressure from the product inside the bag to seal.

All of the valve models closed quickly and tightly at the inner edge of the valve as the nozzle was withdrawn. The main differences between the designs were the unit cost and complication of manufacturing.

In the following subsection, the recommended new valve design is discussed.

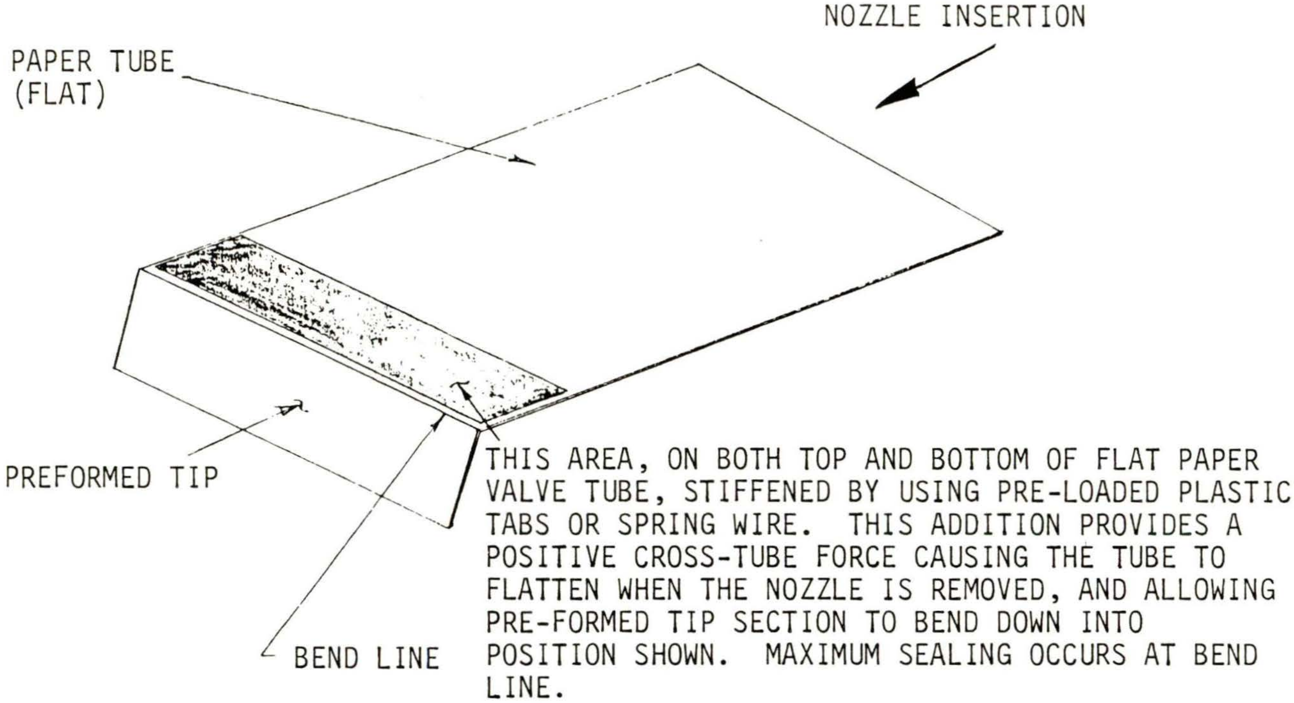


FIGURE 31. - Tube valve with plastic tab.

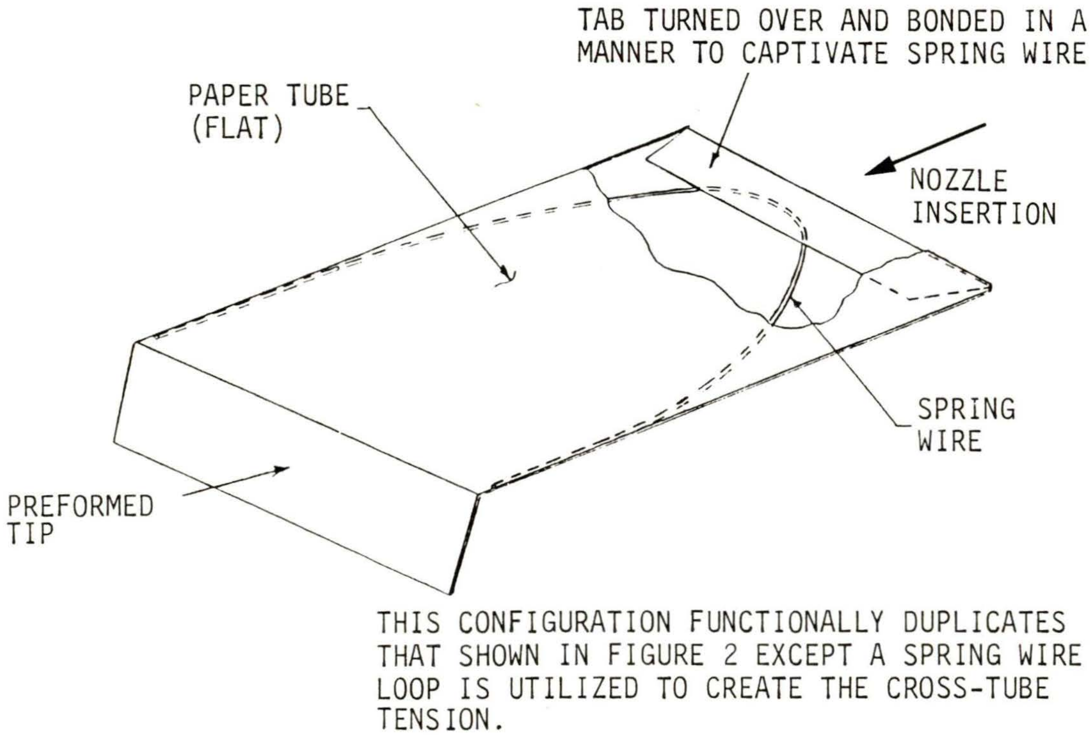


FIGURE 32. - Tube valve with wire loop.

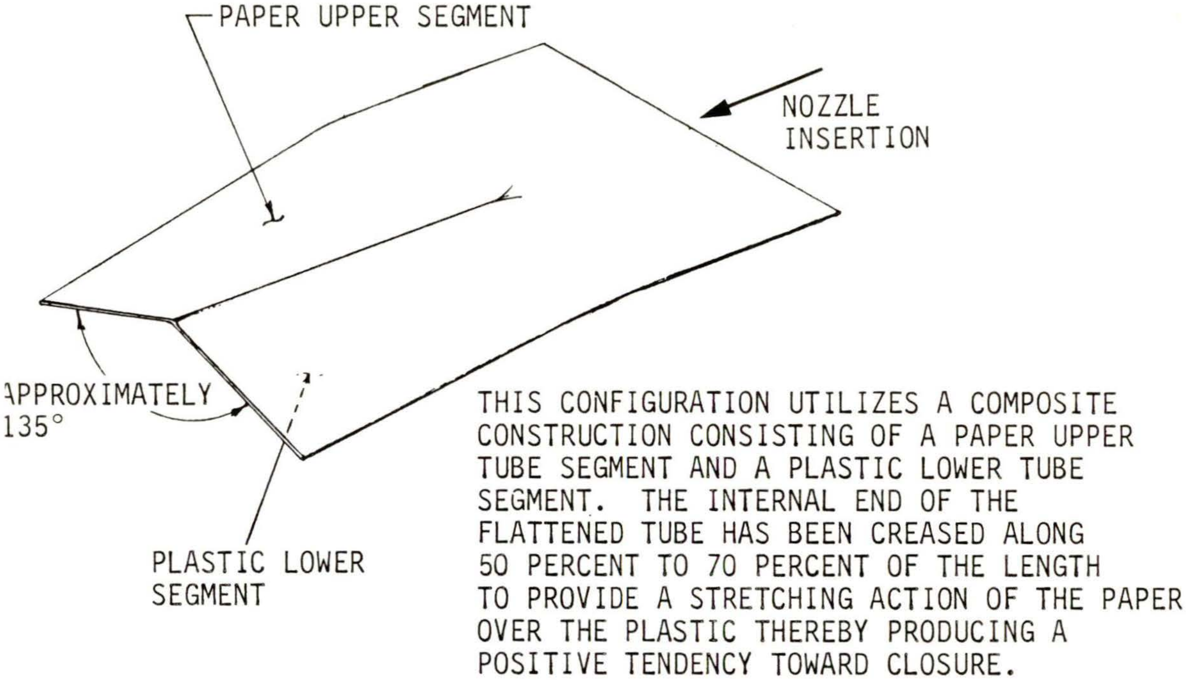


FIGURE 33. - Composite tube valve with center crease.

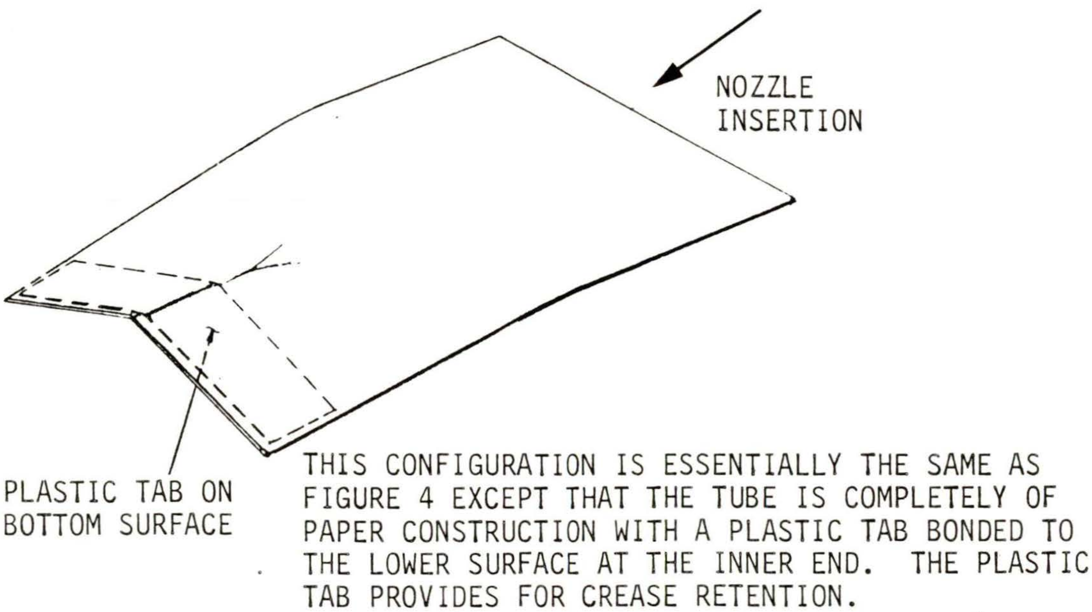


FIGURE 34. - Composite tube valve with plastic tab.

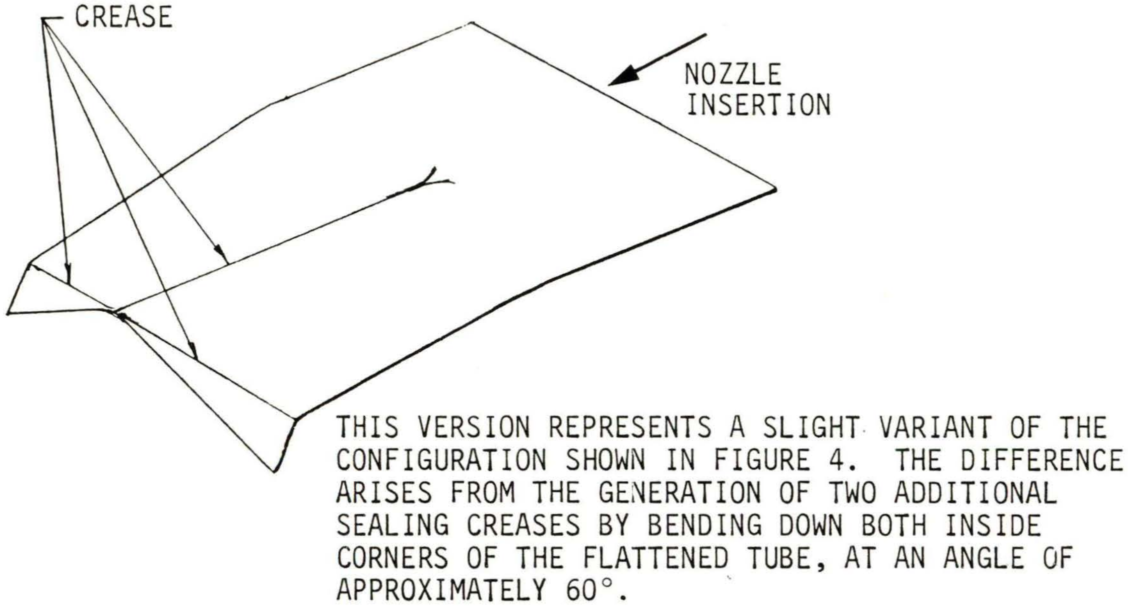


FIGURE 35. - Tube valve with center and end crease.

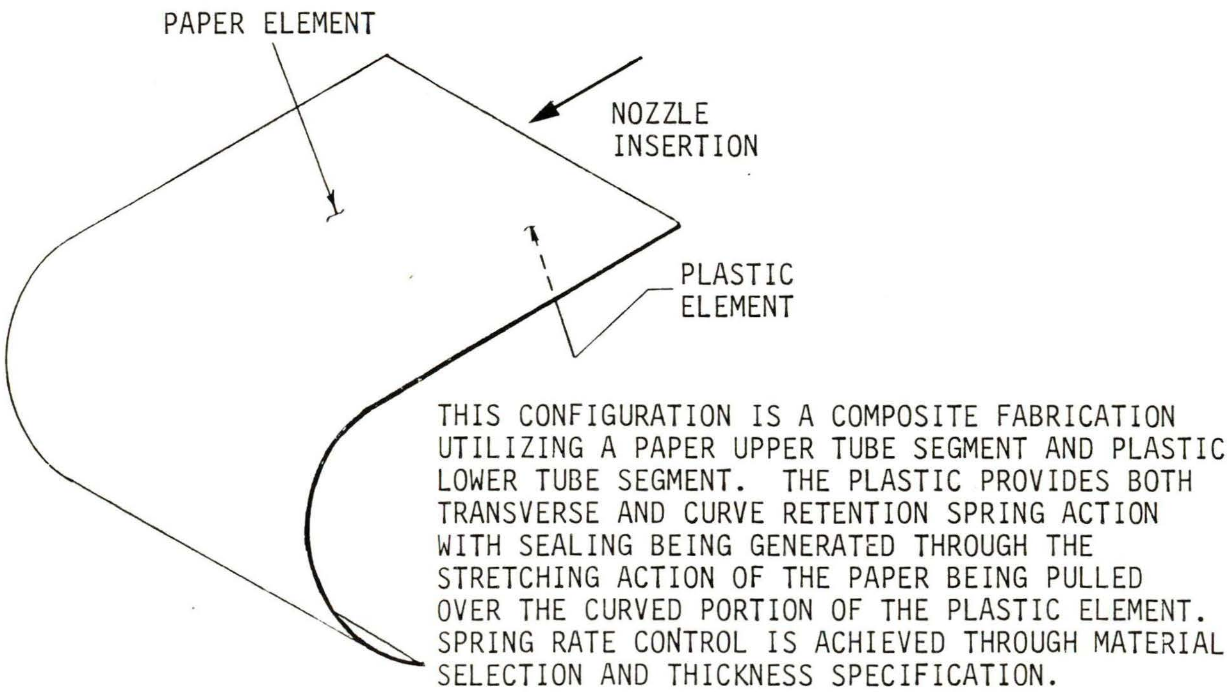


FIGURE 36. - Composite tube valve with curl.

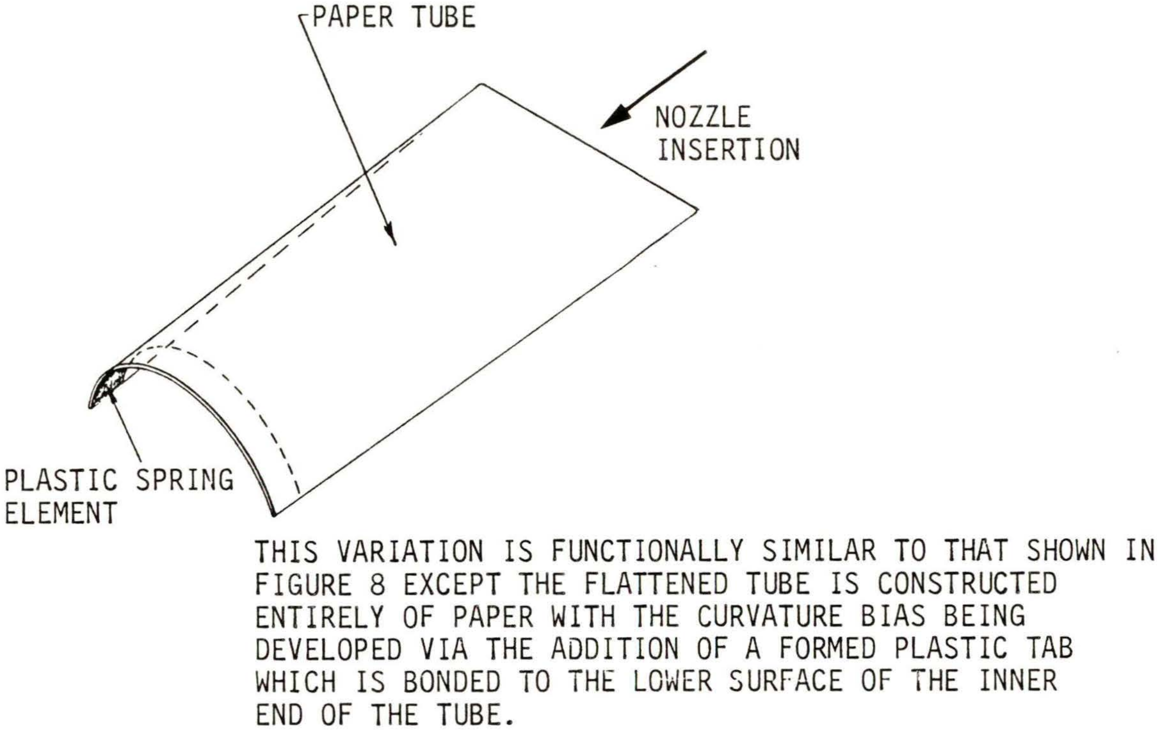


FIGURE 37. - Paper tube valve with plastic spring tab.

4.2.2 Recommended Bag Valve Design

The primary goal of the new valve design was to provide a closed, pre-loaded valve that could be easily opened by the nozzle and would snap shut as the nozzle was withdrawn. All of the concepts presented in section 4.2.1 demonstrated these desired performance characteristics. The recommended valve design, discussed in this section, appeared to be the easiest to manufacture, the least expensive, and the easiest to adapt to the mass production procedures currently used in manufacturing both bags and bag valves.

The recommended design, shown in figure 40, uses a composite construction with a plastic lower and a paper upper element. The valve is post-formed to an approximately 120 to 150^{o} curve either at the inner end only (as shown) or along the entire length. In either case, the installed valve configuration would be approximately as shown. Sealing as the nozzle is withdrawn would occur due to stretching of the paper element over the plastic element.

A potential mass production technique for this valve design is shown in figure 41. The finished valve could be installed into a finished bag from a finished roll of

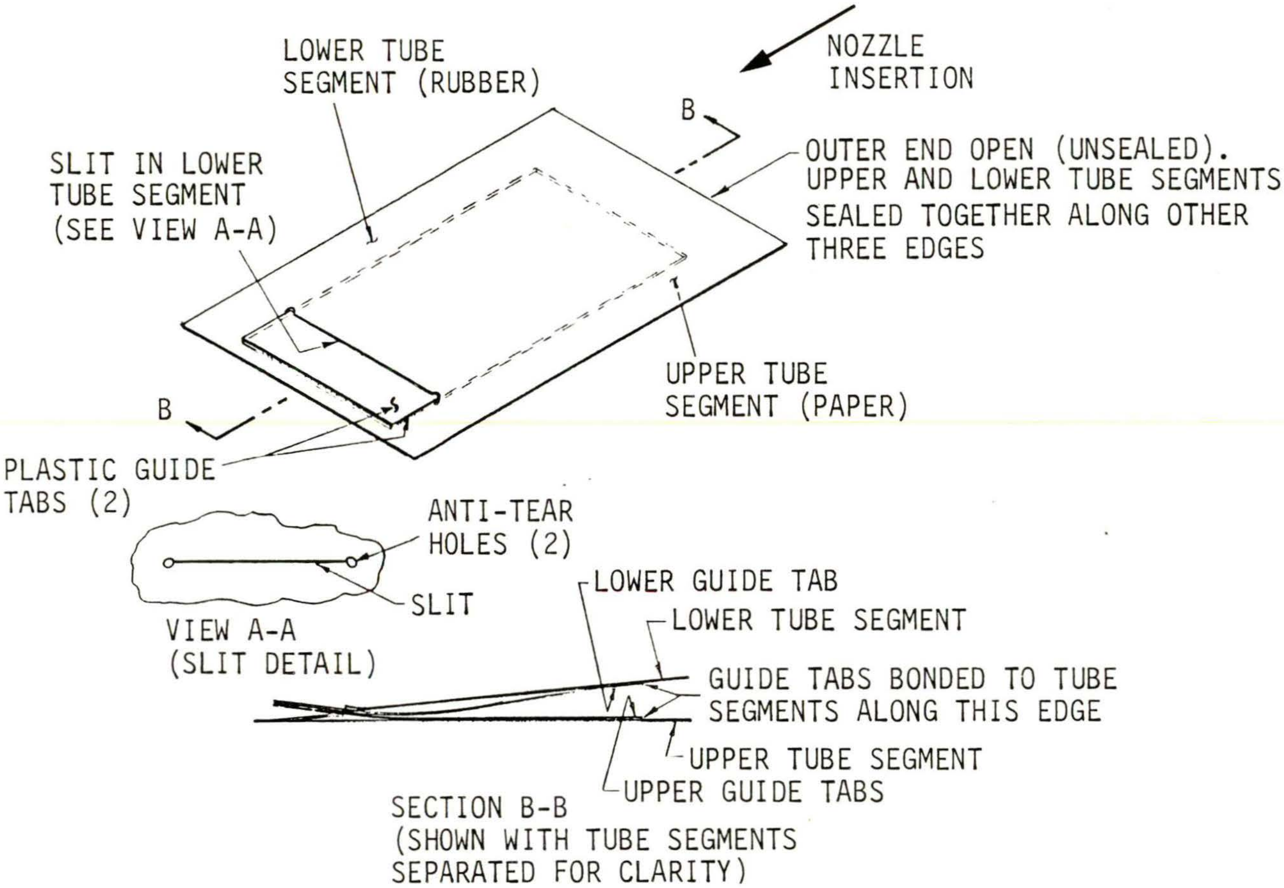


FIGURE 38. - Composite valve paper/rubber with plastic guide.

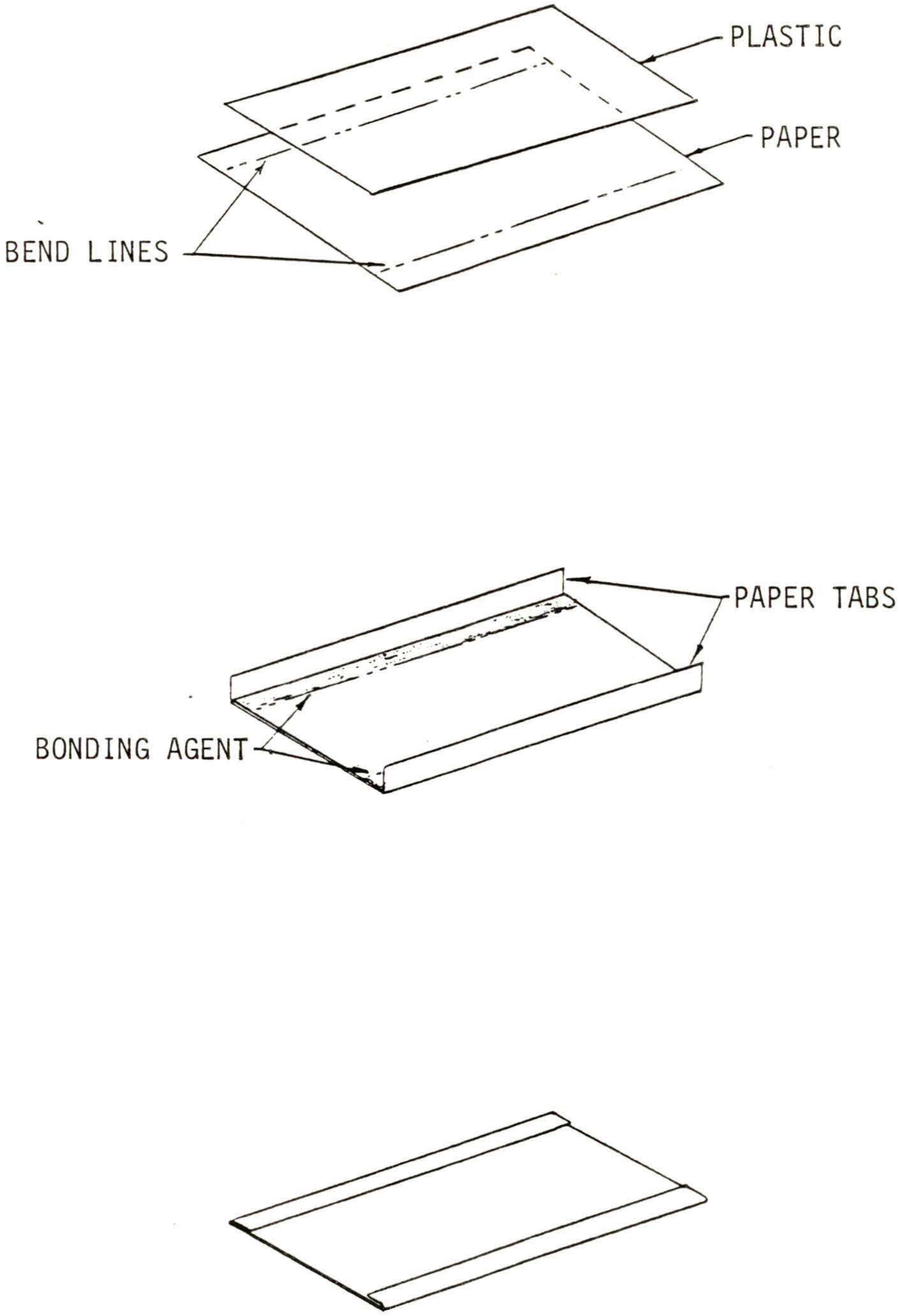


FIGURE 39. - Basic method of construction used to form a tube.

VALVE PARTICULARS

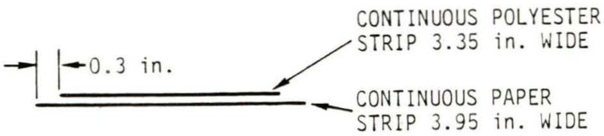
DESCRIPTION - COMPOSITE FLATTENED TUBE, 4 in. TO 4-1/2 in. LONG x 3.35 WIDE (FLATTENED STATE)

MATERIALS - PAPER (UPPER TUBE WALL), 0.010 in. THICK POLYESTER (LOWER TUBE WALL)

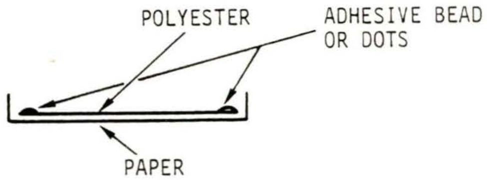
ADHESIVES - PERMABOND 105 (OR EQUIVALENT) OR SUITABLE HOT MELT MATERIAL

SKETCHES -

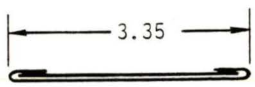
STEP 1 (FEED STOCK)



STEP 2 (FOLD AND APPLY ADHESIVE)



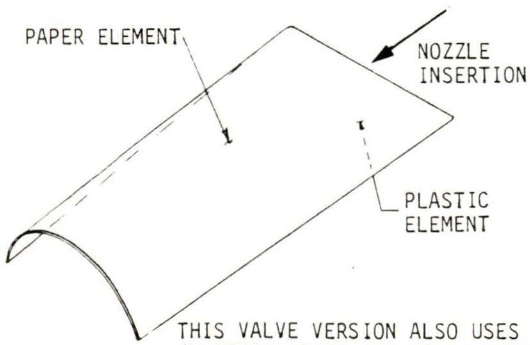
STEP 3 (SEAL)



STEP 4 (FORM)

STEP 5 CUT TO LENGTH

STEP 6 INSTALL IN BMG



THIS VALVE VERSION ALSO USES COMPOSITE CONSTRUCTION (PLASTIC LOWER AND PAPER UPPER ELEMENTS) WHICH ARE POST-FORMED TO AN APPROXIMATELY 120° TO 150° CURVE EITHER AT THE INNER END ONLY (AS SHOWN) OR ALONG THE ENTIRE LENGTH. IN BOTH CASES, THE INSTALLED CONFIGURATION WOULD BE APPROXIMATELY AS SHOWN. SEALING MODE AGAIN IS VIA THE STRETCHING OF THE PAPER OVER THE PLASTIC.

FIGURE 40. - Recommended composite valve design.

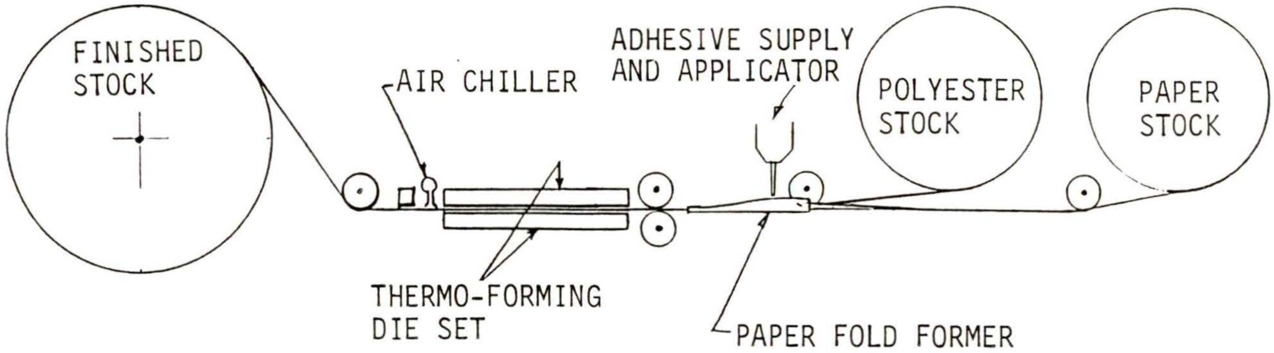


FIGURE 41. - Potential production technique for the recommended new valve design.

valve tubing in the same way that commercially available polyethylene sleeves are currently installed.

The recommended design, when tested with a nozzle, showed easy insertion of the nozzle and quick, tight closing as the nozzle was withdrawn.

The design was submitted to bag manufacturers for critiquing and for an estimate of the cost to manufacture such a valve. They were also asked to provide a cost to manufacture a limited run of bags with the new valve so that it could be evaluated under actual operating conditions. None provided the requested information.

An attempt was made to manufacture and install a limited number of valves for a brief field evaluation. This attempt, however, was unsuccessful and the recommended design was never tested under actual operating conditions.