

PB90199035



Information Circular 9234

# **Development and Testing of a Pneumatic Scraper Blade for Conveyor Belt Cleaning**

**By C. A. Rhoades, S. G. Grannes, and T. L. Hebble**

**UNITED STATES DEPARTMENT OF THE INTERIOR**  
**Manuel Lujan, Jr., Secretary**

**BUREAU OF MINES**  
**T S Ary, Director**

REPRODUCED BY  
U.S. DEPARTMENT OF COMMERCE  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
SPRINGFIELD, VA 22161

**Library of Congress Cataloging in Publication Data:**

**Rhoades, C. A. (Charles A.)**

Development and testing of a pneumatic scraper blade for conveyor belt cleaning.

(Bureau of Mines information circular; 9234)

Supt. of Docs. no.: I 28.27:9234.

1. Conveyor belts--Cleaning. 2. Blades--Testing. I. Grannes, S. G. (Steven G.)  
II. Hebble, T. L. (Terry L.) III. Title. IV. Series: Information circular (United  
States. Bureau of Mines); 9234.

TN295.U4

[TN335]

622 s [622'.66]

89-600122

## CONTENTS

|   | <i>Page</i> |
|---|-------------|
| Abstract .....                            | 1           |
| Introduction .....                        | 2           |
| Experimental procedure .....              | 3           |
| Pneumatic cleaning blade mechanisms ..... | 12          |
| Conclusions .....                         | 12          |

## ILLUSTRATIONS

|   |    |
|---|----|
| 1. Uneven edge wear on blade-type belt cleaners .....                                   | 2  |
| 2. Generic pneumatic blade design .....   | 3  |
| 3. Air distribution system .....  | 4  |
| 4. Manifold pressure versus time for initial pneumatic blade tests .....                | 5  |
| 5. Solid and pneumatic blade edge wear over time .....                                  | 5  |
| 6. Carryback versus manifold pressure .....   | 6  |
| 7. Carryback versus contact pressure .....  | 7  |
| 8. Pneumatic blade edge wear over time for notched blade .....                          | 8  |
| 9. Manifold pressure versus time for notched blade .....                                | 9  |
| 10. Edge wear over time for solid blade .....   | 10 |
| 11. Pneumatic and solid cleaner blade service life versus carryback and wear rate ..... | 10 |
| 12. Wear rate versus time .....   | 11 |
| 13. Dust level measurements .....   | 11 |
| 14. Blade wear mechanisms .....   | 12 |

### UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

|                        |                           |               |                       |
|------------------------|---------------------------|---------------|-----------------------|
| cfm                    | cubic foot per minute     | mil/yr        | mil per year          |
| ft                     | foot                      | $\mu\text{m}$ | micrometer            |
| $\text{g}/\text{ft}^2$ | gram per square foot      | pct           | percent               |
| h                      | hour                      | psi           | pound per square inch |
| in                     | inch                      | s             | second                |
| $\text{mg}/\text{m}^3$ | milligram per cubic meter |               |                       |

# DEVELOPMENT AND TESTING OF A PNEUMATIC SCRAPER BLADE FOR CONVEYOR BELT CLEANING

By C. A. Rhoades,<sup>1</sup> S. G. Grannes,<sup>2</sup> and T. L. Hebble<sup>3</sup>

---

## ABSTRACT

A major contributor to the problem of short life expectancy for blade-type conveyor belt cleaners is uneven wear along the blade edge. Uneven wear results in the formation of channels in the blade edge, which allow material to be carried back between the blade and the belt. In an effort to reduce the uneven wear problem, the U.S. Bureau of Mines has studied the mechanisms responsible for effective belt cleaning. From this study emerged a design for a cleaner blade that would greatly reduce uneven edge wear. The design consists of a standard cleaner blade incorporating air passages that allow for the expulsion of air along that part of the blade edge in contact with the conveyor belt surface. The results of 18-h tests indicated that the expulsion of air on the blade edge prevents scratches from developing into deep grooves. These tests showed that effective blade cleaning life can be extended 25 times using the pneumatic cleaning blade, compared with solid metal cleaning blades.

---

<sup>1</sup>Mining engineer.

<sup>2</sup>General engineer.

<sup>3</sup>Metallurgist.

Twin Cities Research Center, U.S. Bureau of Mines, Minneapolis, MN.

## INTRODUCTION

Conveyors are used throughout the mining and mineral processing industry for transporting high volumes of material over relatively short distances. Conveyors offer several advantages, including continuous material handling, good transport energy efficiency, low labor requirements, and high material-handling capacities. However, several problems are inherent to conveyor transport. These include conveyor adjustment (i.e., belt tracking), system reliability, and system spillage. As part of its health and safety program, the U.S. Bureau of Mines has undertaken a basic study of mechanisms responsible for effective conveyor belt cleaning. Improved cleaner blade design can reduce exposure of mine personnel to dangerous situations, such as explosion, respirable dust, and pinch-point-type hazards, resulting from spillage accumulation on or beneath troughed conveyor belts.

The problem of system spillage was recently examined as part of a 3-year research effort to determine the mechanisms involved in the operation of blade-type belt cleaners. Significant conclusions drawn in this research were that all types of conveyor blade material tend to wear unevenly and that wear preferentially occurs in regions of the blade not in direct contact with the belt.<sup>4</sup> These

regions of wear are called wear channels. Wear channels occur on numerous scraper blade types, including polyurethane, steel with ceramic inserts, tool steel, and mild steel (fig. 1). This research demonstrated that the blade wearout phenomena could be slowed by maintaining proper blade-belt pressures, by eliminating belt irregularities such as metal splices or recessed belt logos, and by increasing blade hardness. With these suggested improvements, blade cleaning life could be approximately doubled, but maximum effective blade life was still generally less than 1 day under laboratory conditions. The possibility of extending blade life even more led to the consideration of the benefits of fluid flow through the wear channels before carryback becomes a problem. The fluid would exit through the minor wear channels until the surrounding blade topography matched the wear channel. Thus, the blade would be self-healing. Fluid flow would prevent particles from corrupting the blade's cleaning edge. Several pneumatic blades were designed and tested, with various combinations of slots or holes in the cleaning blade edge. Slot widths ranged from 0.016 to 0.250 in. The number of holes used in the edge ranged from 6 to 53, with diameters from 0.016 to 0.125 in. This report describes the results of tests with the slotted pneumatic blades compared with solid metal cleaning blades, unless otherwise stated.

<sup>4</sup>Rhoades, C. A., T. L. Hebble, and S. G. Grannes. Basic Parameters of Conveyor Belt Cleaning. BuMines RI 9221, 1989, 19 pp.

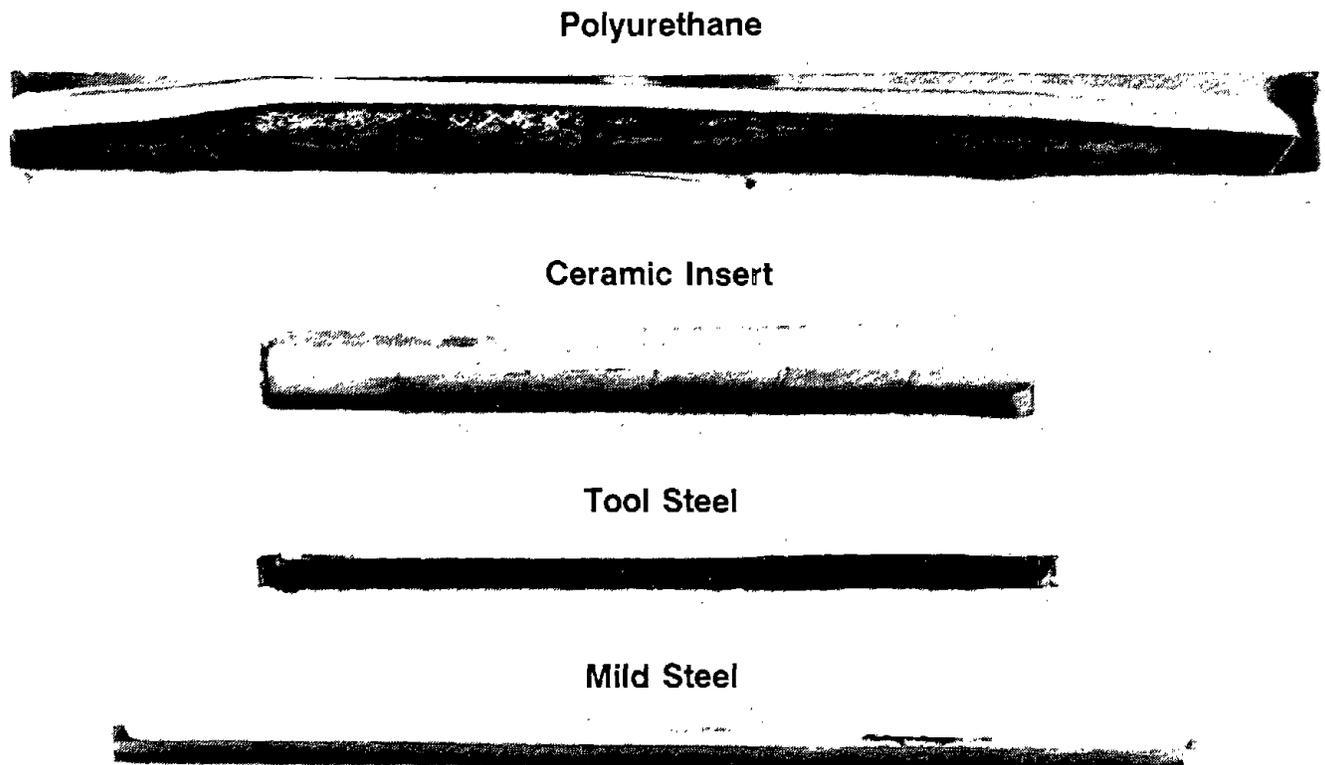


Figure 1.—Uneven edge wear on blade-type belt cleaners. Mild steel blade is 6 in long.

## EXPERIMENTAL PROCEDURE

A series of experiments were designed to test the effectiveness of the pneumatic blade concept. The pneumatic blade consisted of a standard cleaner blade incorporating passages that allowed for the expulsion of water or air along that part of the blade edge in contact with the conveyor belt surface. These experiments were designed to evaluate optimum fluid flow rates and pressures and to develop a theoretical model for the pneumatic blade performance. For a description of the test conveyor belt and the conveyed test mixture, the reader is referred to the previous report.<sup>5</sup> The test procedures used caused highly accelerated blade and component wear.

### Preliminary Testing

Preliminary tests were conducted using a mild (AISI-SAE Type 1045) steel blade with a pressurization slot cut into the blade surface. Water was selected as the fluid because of its low cost, good momentum effects, and lubricating properties. The results from these tests were favorable. The blade remained flat for 8 h of testing with no signs of uneven wear. This was a better result than had been achieved with any solid blade previously tested. However, water was determined to be impractical for this purpose because of serious handling problems in cold climates. For this reason, pressurized air was selected as the fluid for subsequent tests.

Testing with air as the fluid was performed using blades similar to the water blade (fig. 2). Air was delivered to

each pneumatic blade separately by plastic tubing connected to an air distribution system. The air distribution system consisted of a mass-flow meter, four rotameters, and four pressure-dampening reservoirs attached to the laboratory's 80-psi air line. The flow and pressure could be controlled on each blade. The system is shown in figure 3.

Initial tests were conducted at high blade-belt pressures (16 psi) to assure air manifold sealing. Carryback of material was negligible for the duration of these tests, averaging 0.2 g/ft<sup>2</sup>. Figure 4 shows the manifold pressure of the blade for the duration of the test. The initial large increase in pressure during the first half hour indicates the "wearing in" period, in which the blade conformed more closely to the belt, resulting in a tighter seal between the air chamber and the belt. The blade wear that did occur was relatively even and appeared to be the result of fine particles polishing the surface. Development of wear channels would have resulted in a pressure decrease. The pressure increase and stabilization over time showed the tendency of the blades to wear flat (conforming to the belt). Figure 5 compares the cleaning edge of the pneumatic blade after 30 h of service with solid metal cleaner blades after 18 h on the test conveyor. All blades were made from AISI-SAE Type 1045 carbon steel. The solid blades were removed from service because the carryback had increased to over 5 g/ft<sup>2</sup>. The pneumatic blade carryback was less than 0.6 g/ft<sup>2</sup> when the blade was removed from service. Although some smooth contours existed at the ends, the general shape was not consistent with channel wear.

After 30 h of run time in the preliminary test, no evidence of channel formation was apparent, negligible carryback was observed, and manifold pressures were holding at a high level. It appeared as if the test would continue indefinitely until the slot depth was consumed by the flat polishing wear that was occurring. A subsequent test was designed to determine whether existing wear channels could be flattened by the pneumatic blade. In this test, artificial wear channels were machined across the blade edge. Five severe channels were machined to a depth of 0.010 in and a width of 0.125 in. A 1-h series of preliminary setup tests were performed to determine airflow effectiveness limits and blade-belt contact pressure on cleaning. Figure 6 shows the effectiveness of air in reducing carryback at constant blade-belt pressures of 35 and 21 psi. Notice that carryback was significant for both trials with no airflow but was reduced as airflow rates were increased. Figure 7 shows the effect of contact pressure on carryback. Carryback was essentially zero (unmeasurable) for contact pressures of 20 to 25 psi.

<sup>5</sup>Work cited in footnote 4.

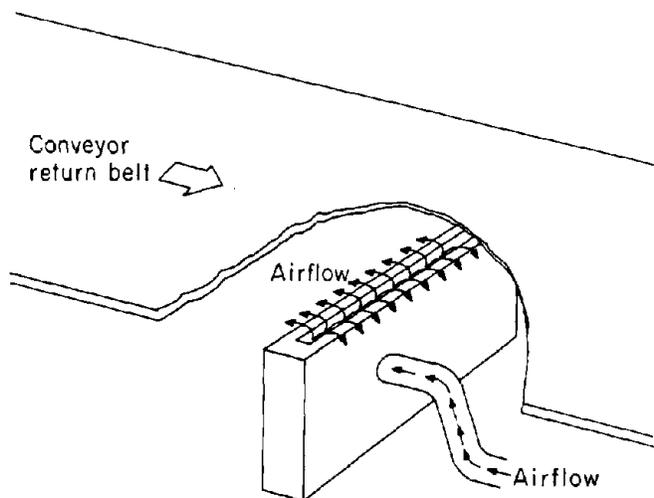


Figure 2.—Generic pneumatic blade design.

### Long-Term Wear Testing

Based on these tests, a long-term wear test to determine the pneumatic blade's ability to correct the artificial wear channels was designed. The blade-belt pressure for this test was set at 20 psi, and the manifold pressure was set at 20 psi. Figure 8 shows the profile of blade 2 during the 21-h test. Figure 9 shows the manifold pressures over the test interval. Notice the gradual smoothing of the blade and the corresponding increase in manifold pressures. Figure 10 shows a typical solid cleaner blade with time. The troughs form and widen as time goes on. The solid blades were removed from service between 12 and 18 h because the carryback increased to over 5 g/ft<sup>2</sup>. The pneumatic blade did not develop the wear pattern of the solid blade. The air being forced through the blade prevented abrading and eroding particles from localized attack on the blade. This is shown in figure 8 by the even wear of the blade near the air slot. The comparison of the two blades in figures 8 and 10 shows the "self-healing" nature of the pneumatic blade by the gradual total surface wear and the elimination of the starting notches. The pneumatic blade experiment was stopped at 21 h with no indications of uneven wear. The carryback was less than 0.6 g/ft<sup>2</sup>.

Because of flat wear, the service life of the pneumatic blade is significantly greater than that of conventional solid blades. Figure 11 contrasts the carryback amounts and wear rates for conventional solid blades and the pneumatic blade. Wear channels in the solid blade cause a significant carryback amount of 2 g/ft<sup>2</sup> after 5 h and 6 g/ft<sup>2</sup> in 24 h. These wear channels are illustrated in figure 10. The pneumatic blade carryback remained stable at 0.5 g/ft<sup>2</sup>—one-tenth the carryback of the solid blade at the conclusion of the test interval. Although the pneumatic blade has a 33-pct higher average wear rate, the wear pattern is flat (figs. 5, 8). This evidence suggests that the service life of the pneumatic blade is limited only by the air chamber depth and would be about 500 h under the accelerated test conditions. Since wear rates can be decreased by using harder steels, this service life could be further extended.

The pneumatic blade wear rate is affected by the total airflow through the system and through each individual blade. The wear data in figure 12 show the decreasing wear rate for increased airflow. The airflow was not increased beyond 34 cfm because of the dust created and to prevent the lifting of the blade's cleaning edge away from the belt. A balance of airflow, surface treatment, and design should optimize the cleaner blade for each individual conveyor and the material conveyed.

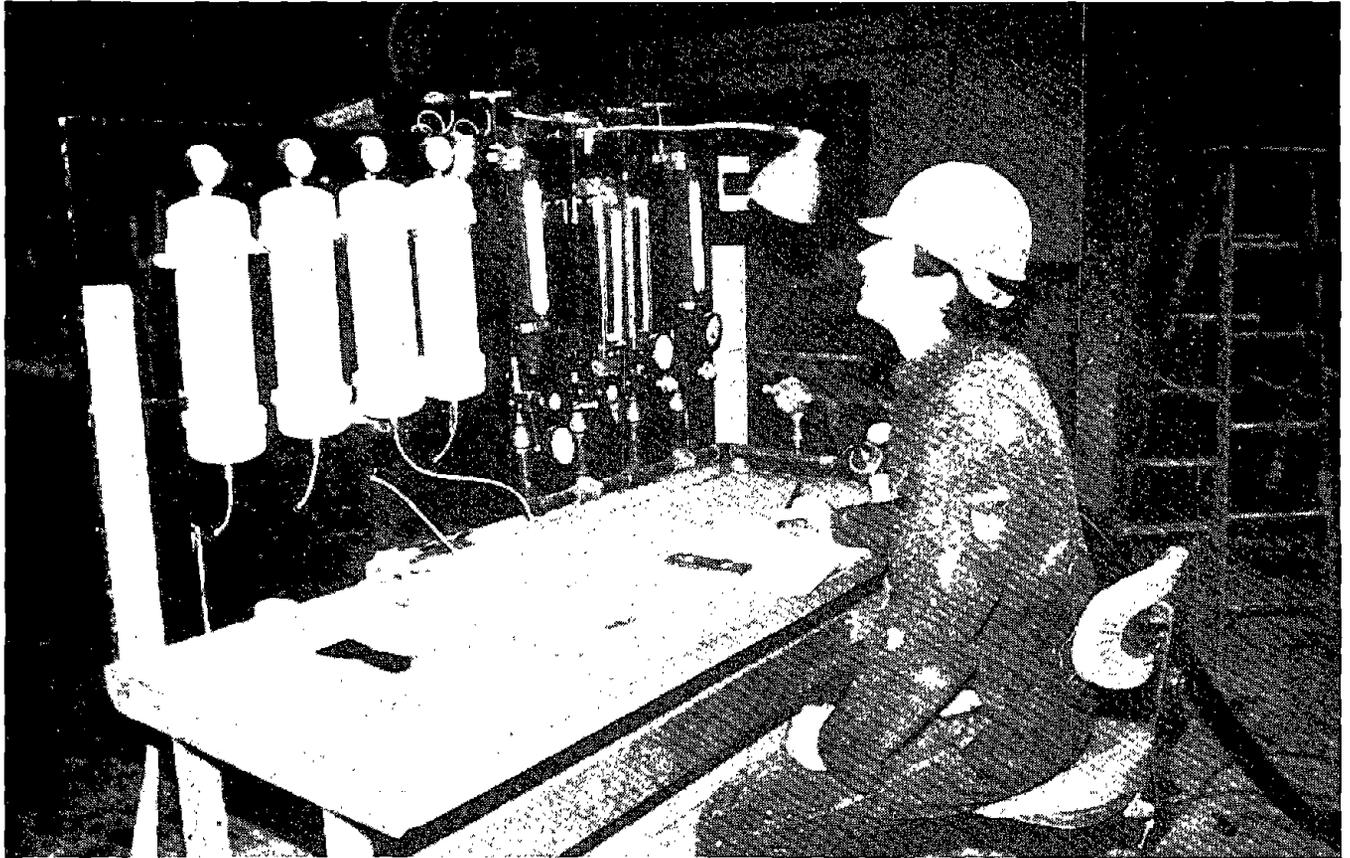


Figure 3.—Air distribution system.

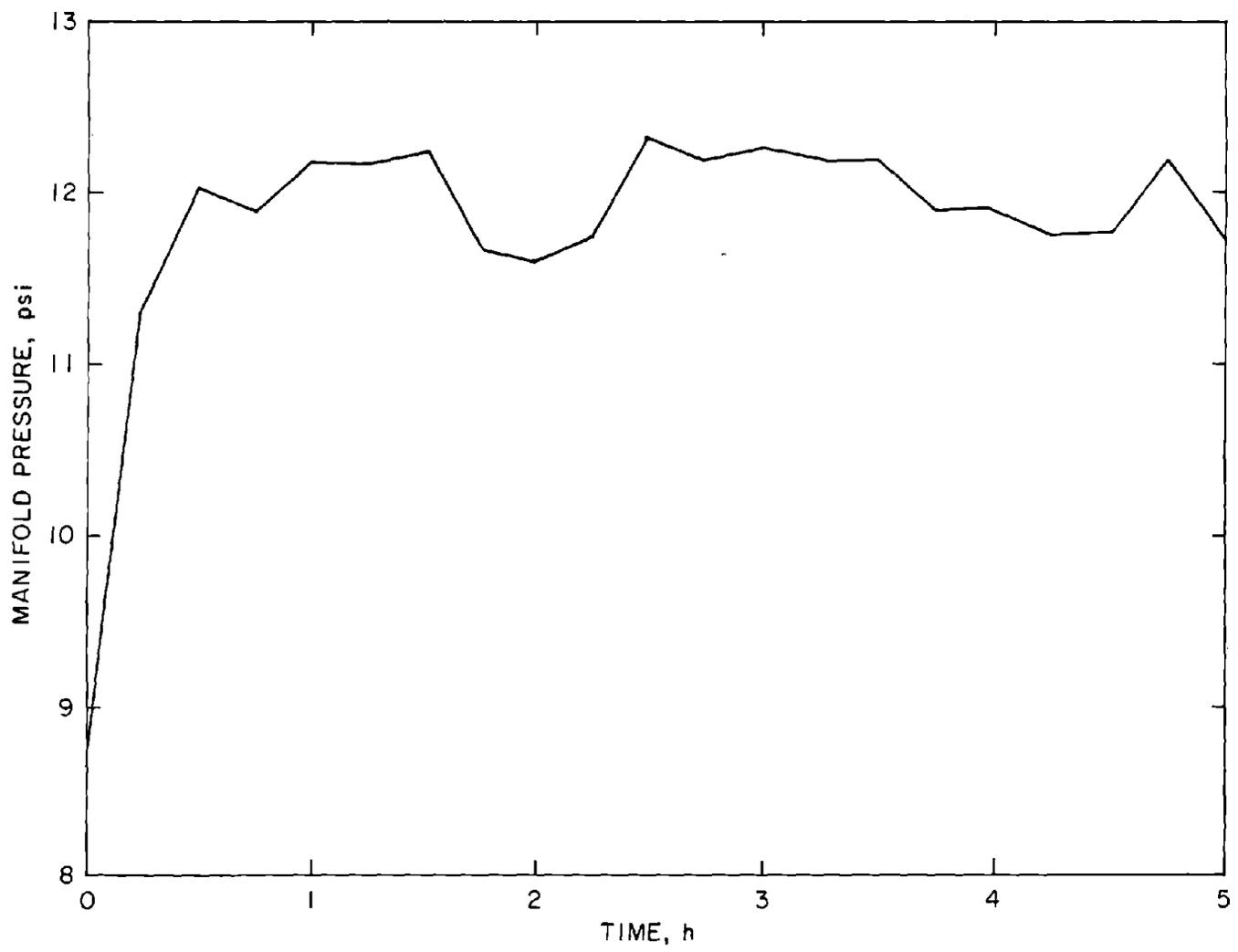


Figure 4.-Manifold pressure versus time for initial pneumatic blade tests.



Figure 5.-Solid and pneumatic blade edge wear over time. A, Solid blade, 18 h; B, pneumatic blade, 30 h.

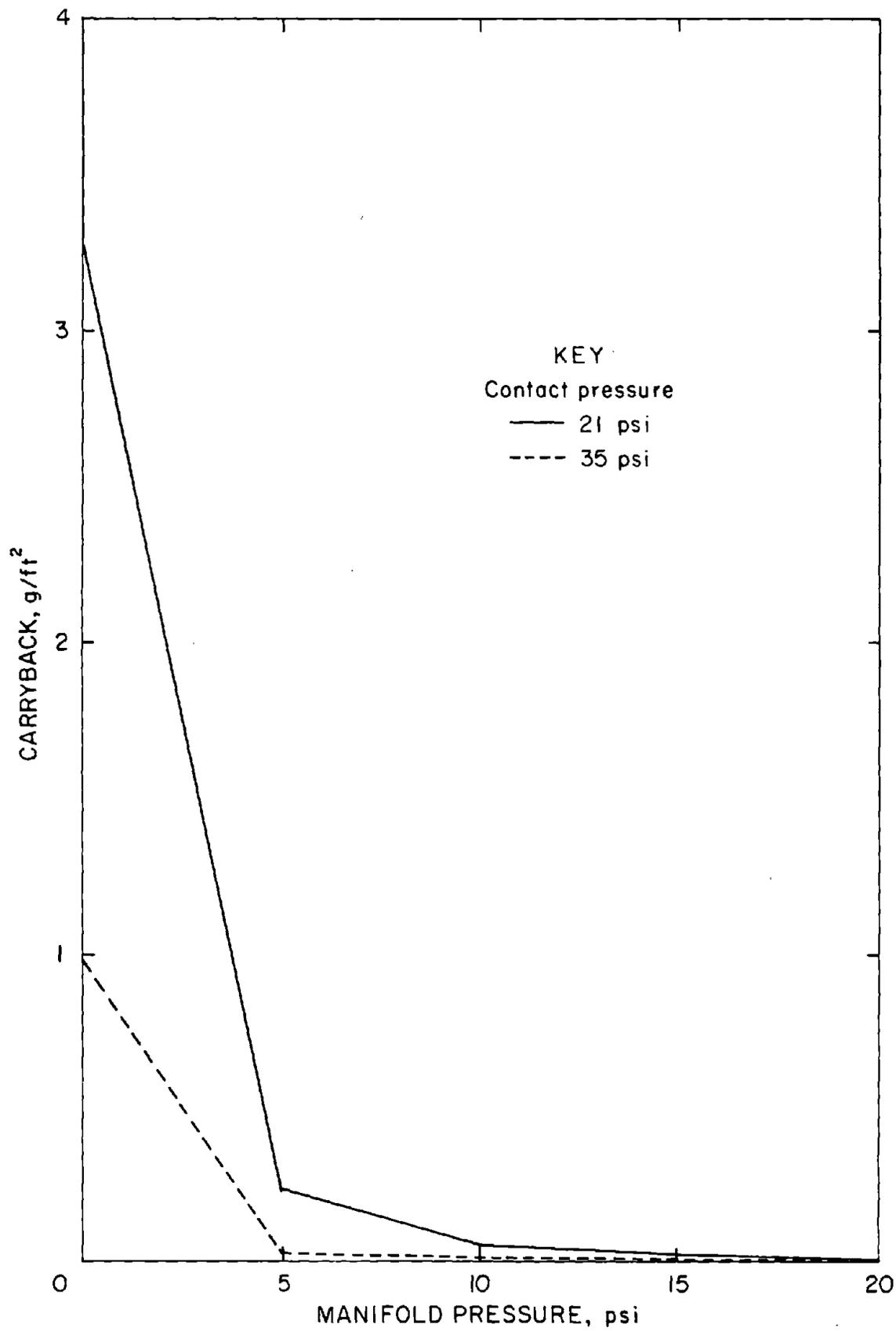


Figure 6.-Carryback versus manifold pressure.

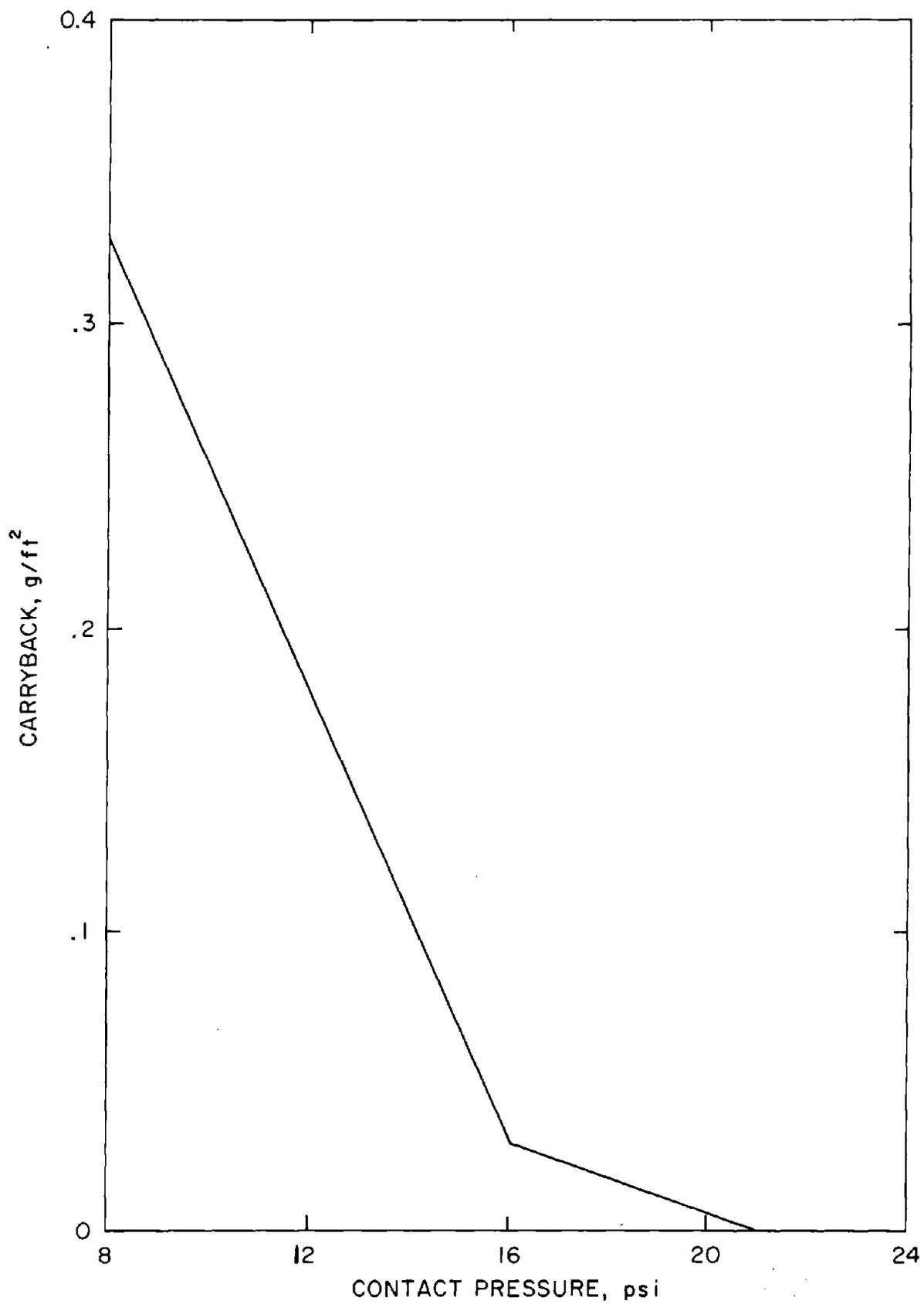


Figure 7.-Carryback versus contact pressure.

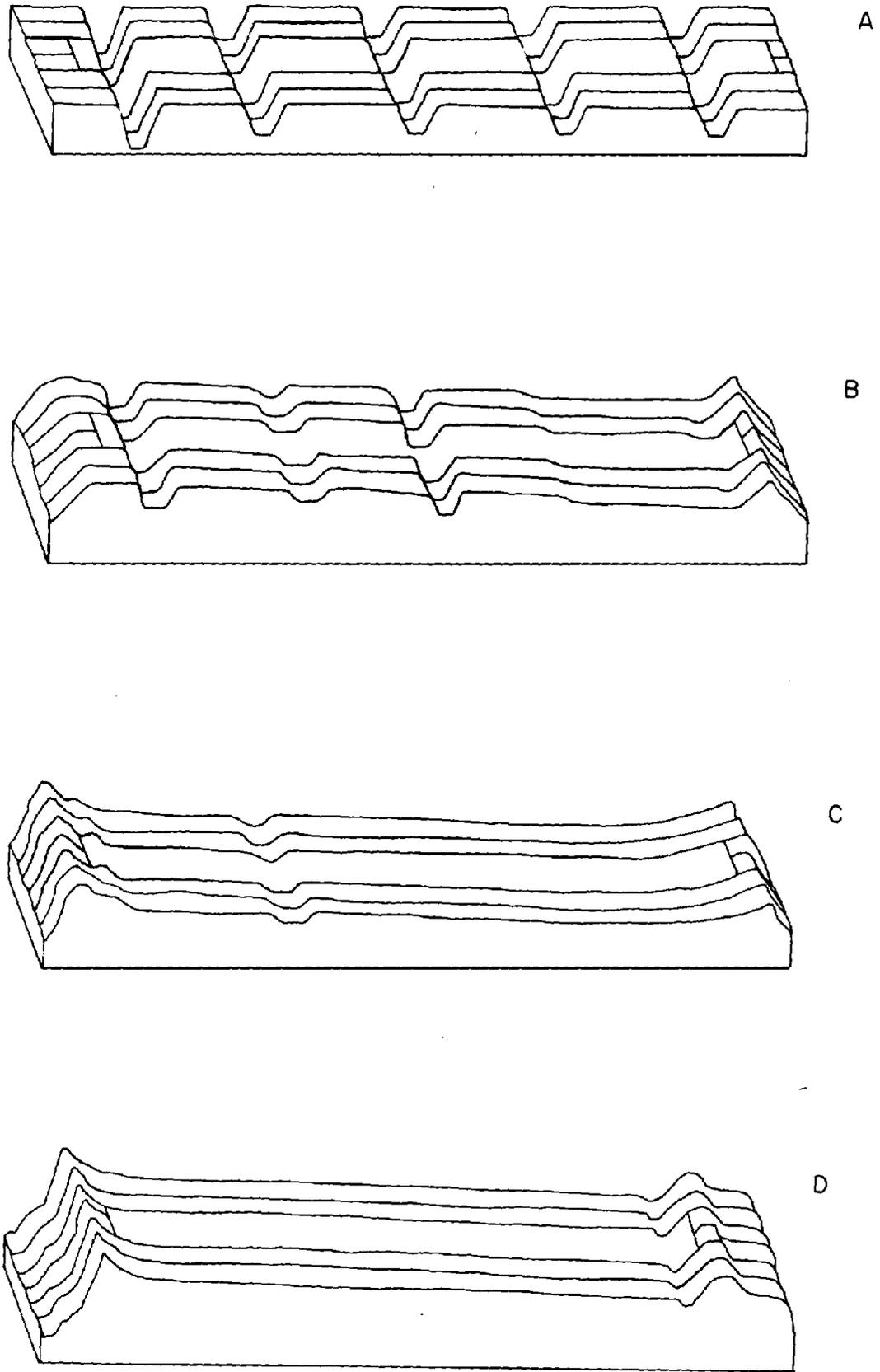


Figure 8.-Pneumatic blade edge wear over time for notched blade. A, 0 h; B, 6 h; C, 11 h; D, 21 h.

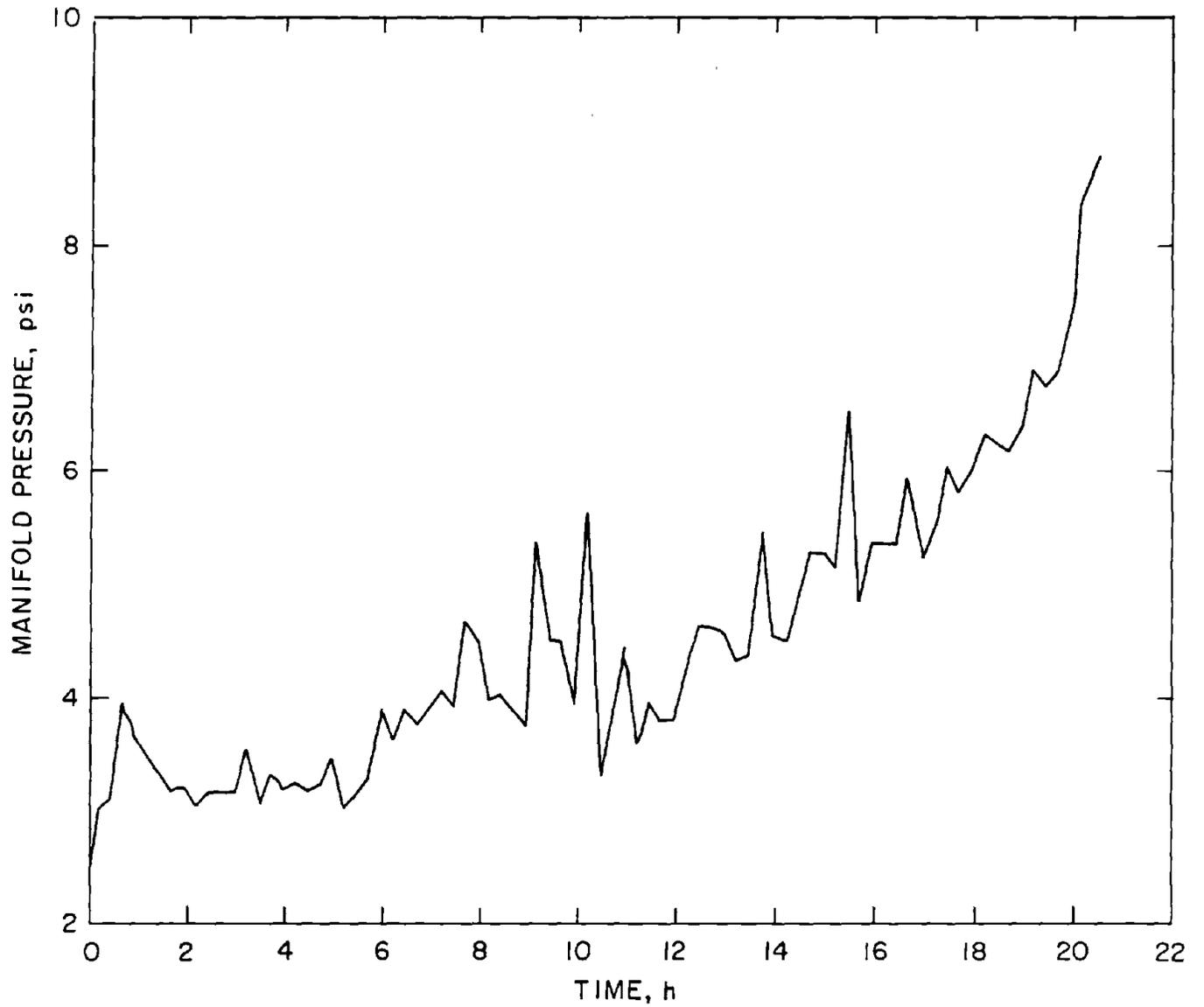


Figure 9.-Manifold pressure versus time for notched blade.

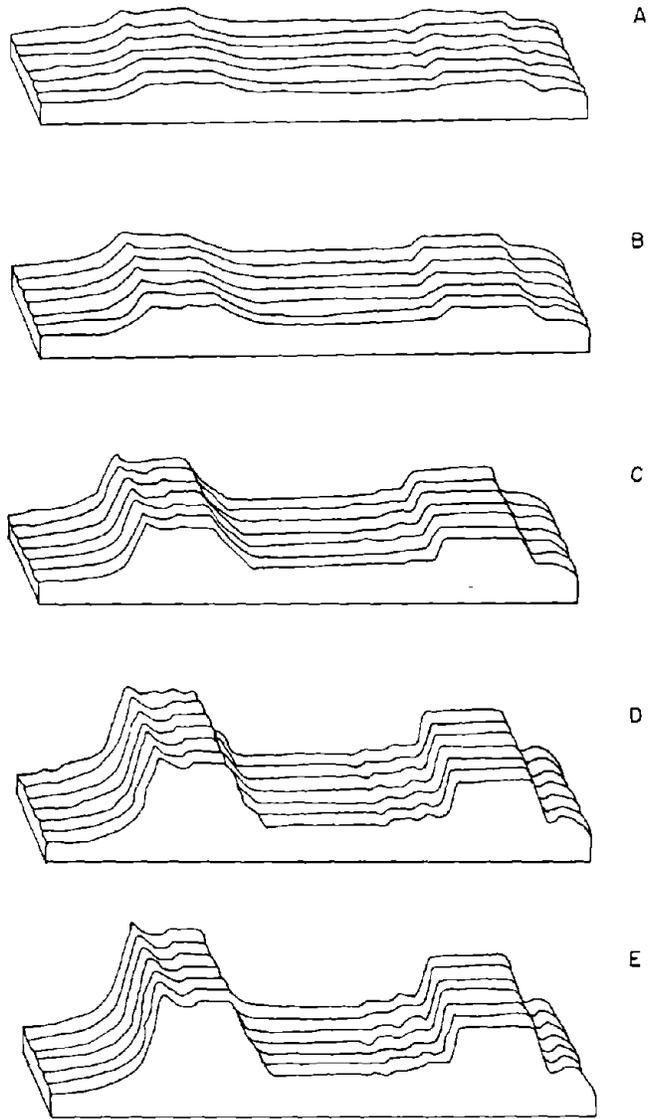


Figure 10.—Edge wear over time for solid blade. A, 3 h; B, 5 h; C, 10 h; D, 15 h; E, 18 h.

Dust Generation

One additional parameter noted during the testing was dust generation. The research conveyor was housed in a 50- by 75- by 15-ft building. A GCA RAM-1<sup>6</sup> dust monitor was used to measure respirable dust levels. The operation and performance of this instrument have been described in the literature.<sup>7</sup> The instrument can be operated in three concentration ranges of 0 to 2.0, 0 to 20, and

<sup>6</sup>Reference to specific products does not imply endorsement by the U.S. Bureau of Mines.

<sup>7</sup>Lilienfeld, P. Improved Light Scattering Dust Monitor (contract HO377092, GCA Corp.). BuMines OFR 90-79, 1979, 48 pp.; NTIS PB 299-938.

Williams, K. L., and R. J. Timko. Performance Evaluation of a Real-Time Aerosol Monitor. BuMines IC 8968, 1984, 20 pp.

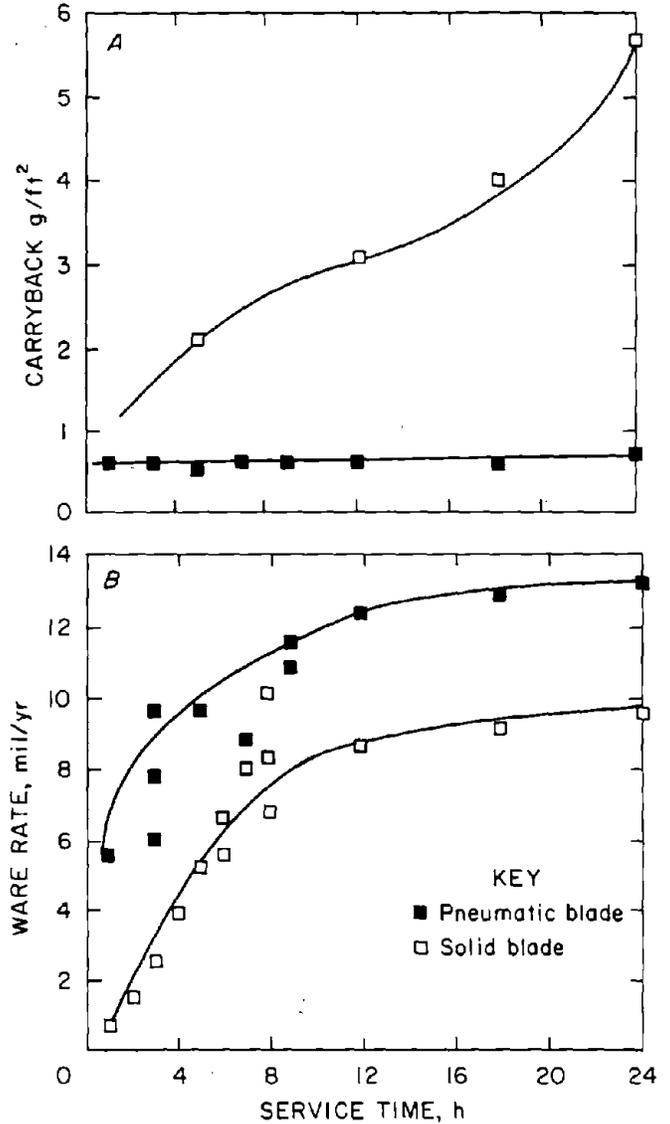


Figure 11.—Pneumatic and solid cleaner blade service life versus carryback and wear rate.

0 to 200 mg/m<sup>3</sup>, and in four measurement time constants of 0.5, 2, 8, and 32 s. The RAM-1 was operated with a cyclone precollector for particle size selection, which permitted particles less than 10 μm in diameter. Calibration was done with an Arizona road dust. The monitor was calibrated before and after each run. A time constant of 8 s and a range of 0 to 20 mg/m<sup>3</sup> were used. The monitor was placed 10 ft in front of the head pulley and 10 ft above the floor. Figure 13 shows the respirable dust levels during a 3-h test run with a solid blade and three pneumatic blades. The pneumatic blades had either six 0.125-in-diameter holes, fifty-two 0.016-in-diameter holes, or a 0.026-in continuous slot. The dust levels increased to a maximum of 2.5 mg/m<sup>3</sup> during the 3-h run. These levels are well below the maximum level of 5 mg/m<sup>3</sup> allowed by the U.S. Mine Safety and Health Administration and the U.S. Occupational Safety and Health Administration.

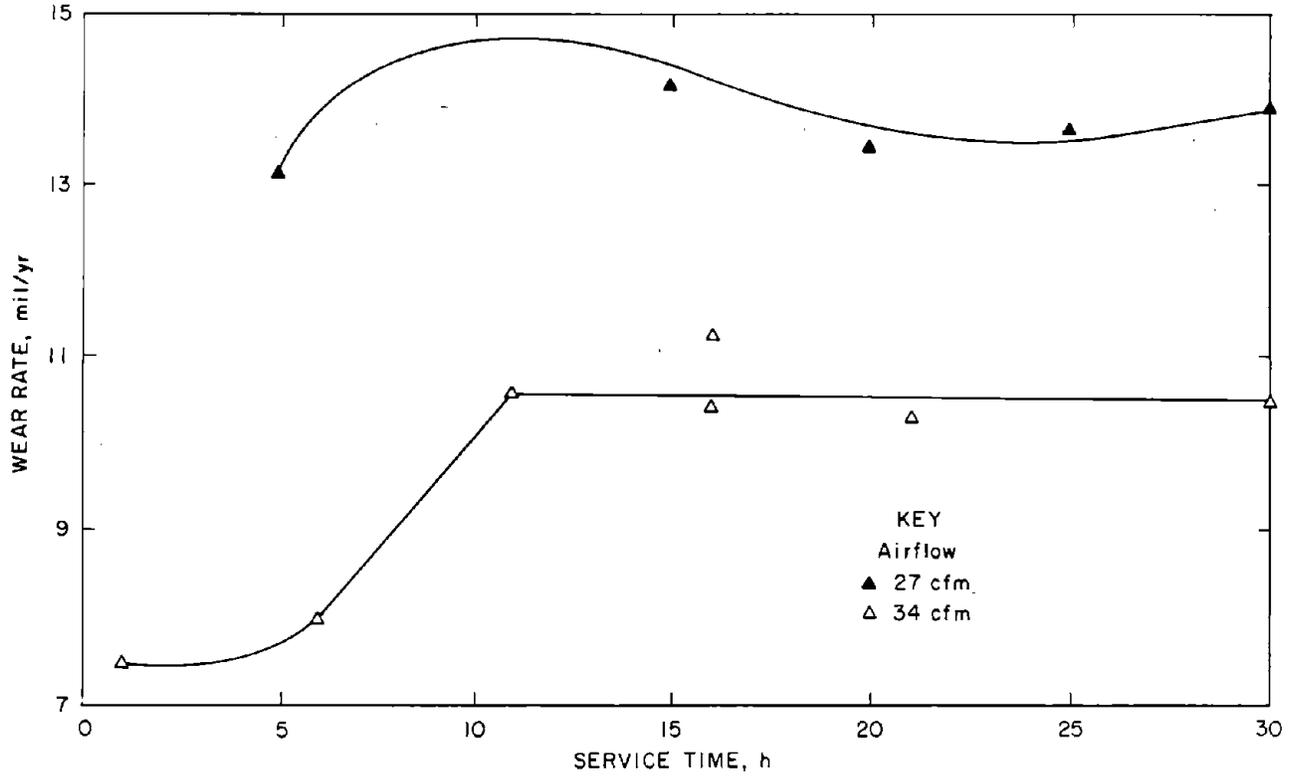


Figure 12.-Wear rate versus time.

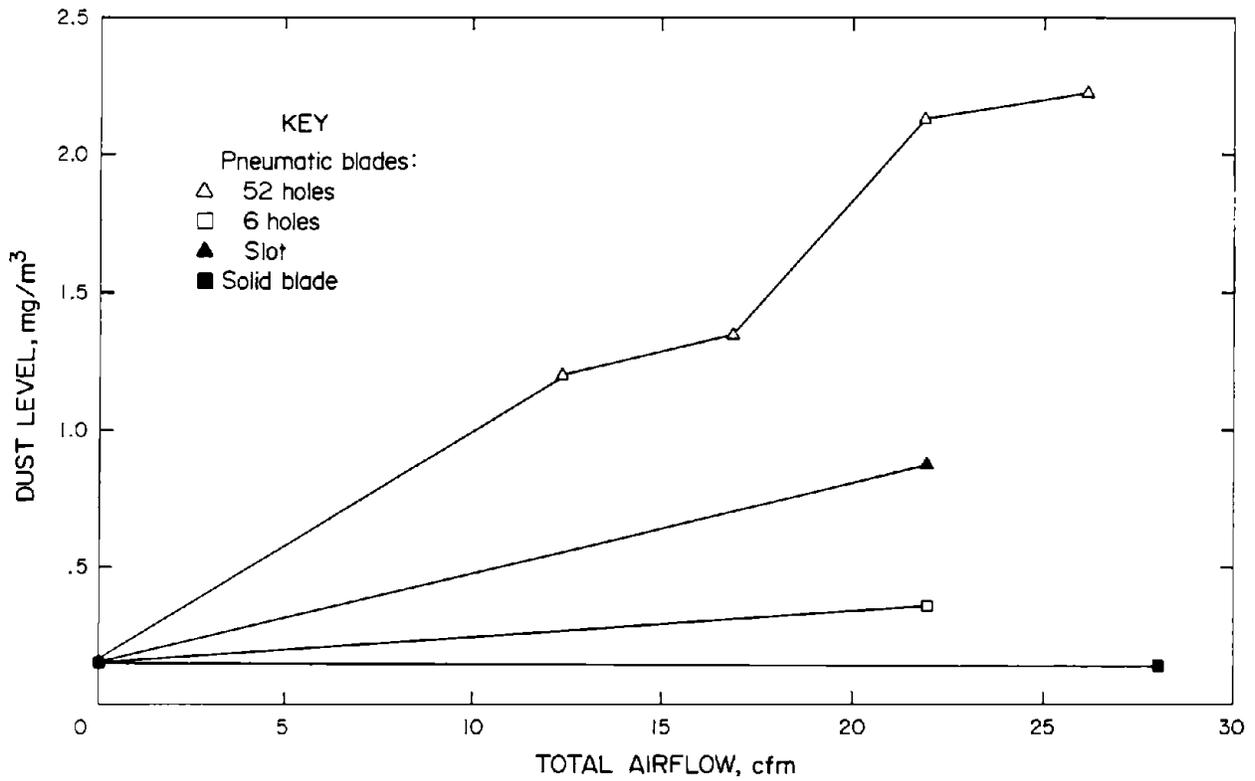


Figure 13.-Dust level measurements.

## PNEUMATIC CLEANING BLADE MECHANISMS

Two mechanisms were found to contribute to uneven blade wear: particle wedging and viscous material flow. These mechanisms contribute to a blade-belt contact interface that could be described as being in a state of unstable equilibrium. The blade-belt interface will remain flat as long as no external disturbance occurs, such as a random particle gouge or a belt imperfection that causes a wear channel to begin. The concept of the pneumatic blade originated as a method of bringing the contact interface into a state of stable equilibrium. The idea was that a fluid emanating from the blade-belt interface would stabilize the contact interface by preventing preferential particle wedging and viscous material flow. The momentum and pressure of the fluid should preferentially restrict abrasive particles from entering possible wear channel growth areas. The fluid can be thought of as stabilizing the scraper blade cleaning process but not doing the actual cleaning. These concepts are illustrated in figures 2 and 14.

If the pressure of the air within the manifold is kept within certain limits relative to the blade-to-belt contact pressure, air will be expelled along scratches, preventing further entrapment of abrasive particles. The parameters critical to the efficient operation of the pneumatic cleaner blade include (1) the blade-to-belt contact pressure, (2) the air pressure used in the blade, and (3) the shape and size of the air exit hole in the blade edge.

The blade-to-belt contact pressure must be kept significantly above the critical pressure<sup>8</sup> to avoid intermittent loss of cleaning efficiency because of fluctuations in air pressure and irregularities in the drum and belt surface. If the contact pressure is near the critical pressure, fluctuations in pressure and belt and drum surface could be sufficient to allow enough separation of the blade from the belt to result in the loss of significant quantities of air.

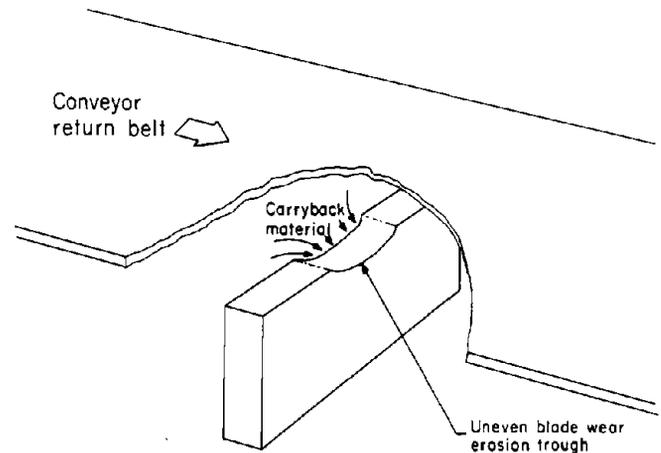


Figure 14.—Blade wear mechanisms.

The problem with using solid blades at pressures significantly above the critical contact pressure has been the high friction between the blade and belt, resulting in high drive motor current draw. With pneumatic blades, however, high contact pressure is not as much of a problem because the escaping air acts as a lubricant, which reduces the friction.

The pressure of the air expelled along the contact edge of the blade must be kept below the blade-to-belt contact pressure. Air pressures at, or above, the contact pressure would result in the blade's being lifted off the belt. This would result in two problems: The edge of the blade would not be in position to scrape the carryback off the belt, and the gap between the blade and belt would allow the escape of large quantities of air as well as generation of excessive dust.

## CONCLUSIONS

The results of the testing program have shown that the pneumatic blade design can prevent the creation and

enlargement of wear channels on the cleaner blade edge, which occur on conventional solid blades. While the overall wear rate is slightly higher, the wear occurs evenly along the edge. This even wear results in a considerably longer useful life expectancy for the pneumatic blade design.

<sup>8</sup>The minimum pressure for which incremental pressure increases do not result in increased cleaning effectiveness.

|  |                                  |   |   |
|--|----------------------------------|---|---|
| REPORT DOCUMENTATION<br>PAGE   | 1. REPORT NO.<br>BuMines IC-9234 | 2.<br>PB 90   | 3. Recipient's Accession No.<br>199035/AS |
| 4. Title and Subtitle<br>Development and Testing of a Pneumatic Scraper Blade for<br>Conveyor Belt Cleaning  |                                  | 5. Report Date  |   |
| 7. Author(s)<br>C. A. Rhoades, S. G. Grannes, and T. L. Hebble   |                                  | 8. Performing Organization Report No.   |   |
| 9. Performing Organization Name and Address<br>Twin Cities Research Center<br>Bureau of Mines<br>5629 Minnehaha Avenue South<br>Minneapolis, MN 55417  |                                  | 10. Project/Task/Work Unit No.<br><br>11. Contract(C) or Grant(G) No.<br>(C)<br>(G) |   |
| 12. Sponsoring Organization Name and Address<br>Office of Assistant Director<br>Bureau of Mines<br>U.S. Department of Interior<br>Washington, D.C. 20241   |                                  | 13. Type of Report & Period Covered<br><br>14.                                      |   |
| 15. Supplementary Notes  |                                  |   |   |
| 16. Abstract (Limit 200 words)<br><br>A major contributor to the problem of short life expectancy for blade-type conveyor belt cleaners is uneven wear along the blade edge. Uneven wear results in the formation of channels in the blade edge, which allow material to be carried back between the blade and the belt. In an effort to reduce the uneven wear problem, the Bureau of Mines has studied the mechanisms responsible for effective belt cleaning. From this study emerged a design for a cleaner blade that would greatly reduce uneven edge wear. The design consists of a standard cleaner blade incorporating air passages that allow for the expulsion of air along that part of the blade edge in contact with the conveyor belt surface. The results of 18-h tests indicated that the expulsion of air on the blade edge prevents scratches from developing into deep grooves. These tests showed the effective blade cleaning life can be extended 25 times using the pneumatic cleaning blade, compared with solid metal cleaning blades. |                                  |   |   |
| 17. Document Analysis & Descriptors<br>Conveyor belt cleaner<br>Pneumatic scraper blades<br>Fluid scraper blades<br>Conveyor belt spillage<br>B. Identifiers/Open-Ended Terms<br>None<br><br>C. COSATI Field/Group 13/07 Mechanical Industrial Civil Marine Engineering Hydraulic/Pneumat  |                                  |   |   |
| 18. Availability Statement   |                                  | 19. Security Class (This Report)  | 21. No. of Pages                          |
|  |                                  | 20. Security Class (This Page)  | 22. Price                                 |

1