

RETROFIT NOISE CONTROLS FOR CRUSHING AND SCREENING PLANTS

By Terry L. Muldoon¹ and Thomas G. Bobick²

ABSTRACT

Crushing and screening equipment in the sand and gravel and crushed stone industries generate excessive noise. Plant operators and cleanup personnel receive a full-shift exposure that ranges from three to four times the exposure allowed by Federal regulations. Noise is typically generated by the impact of the product against the steel components of the plant. The impact forces cause the components to resonate and create airborne noise.

During a Bureau of Mines sponsored research program, retrofit noise control

treatments were successfully installed and evaluated in a primary crushing plant and two secondary crushing and screening plants. A control booth was installed at the primary crushing plant; the noise levels at the operator's location were reduced from 97 to 78 dBA. Noise levels measured at normal cleanup locations were reduced by 4 to 7 dBA (97.5-98 to 91-93.5 dBA) at one of the two secondary plants. This paper describes how to design, select, and install similar retrofit noise control treatments for crushing and screening plants.

INTRODUCTION

A 1981 Bureau of Mines study³ showed that the full-shift noise exposure of operators and cleanup personnel in crushing and screening plants were three to four times the exposure allowed by 30 CFR, Part 56, "Safety and Health Standards--Sand, Gravel, and Crushed Stone Operations." The study also identified the following major noise sources as the chief contributors to the overexposure problem.

a. Screen feed chute. Typically, material enters the screen through a steel chute from a belt conveyor. The product discharged from the conveyor impacts the sides, wall, and bottom of the steel chute.

b. Screen feedbox. Additionally, the product discharging from the screen feed chute impacts a steel screen feedbox that is an integral part of the screen.

c. Screen. The normal screening medium is either punched steel plate or woven wire cloth. Some screens are furnished with steel side wings. High noise levels are generated by the impact of the product on both the deck and wing liners.

d. Screen discharge. Typically, the oversize product from the top screen deck drops onto a steel discharge lip or directly from the screen onto a steel plate in the crusher. The undersize product passes through the screening medium and impacts a discharge chute, transfer conveyor, or another screen deck.

e. Crusher feed hopper or chute. The feed to the crusher impacts a cylindrical or conical collection hopper that directs the feed into the crushing cavity. Often the feed to the crusher is sparse and the impacting product strikes the hopper individually. A heavily fed (choke-fed) crusher has the opportunity for a bed of

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³Pokora, R. J., and T. L. Muldoon. Demonstration of Noise Control Techniques for the Crushing and Screening of Non-metallic Minerals (contract J0100038, Foster-Miller, Inc.). BuMines OFR 50-83, 1981, 187 pp.; NTIS PB 83-173039.

material to build up and, therefore, attenuate the noise.

f. Crusher feed plate. Most cone crushers are supplied with an abrasion-resistant metal feed plate. Product dropping into the crusher strikes the feed plate--particularly if the crusher is not choke fed.

g. Crusher feed cone. Typically, the feed cone is lined with manganese steel plate for wear. The product fed to the crusher strikes the feed cone.

h. Crusher main frame. The shell surrounding the crushing cavity typically is impacted by product discharging from inside the crusher. The shell acts as a radiator for all of the noise generated in the product reduction process from within the crusher itself.

i. Crusher discharge. The product discharged from the crusher is typically transferred via another steel chute to a belt conveyor that transports it to the

next comminution stage or to a stockpile. These sources are common to all crushing and screening plants and are accessible without major disassembly of the plant. The noise associated with each of these sources is generated by the impact of the product on the steel components of the plant, which then resonate, creating airborne noise.

During the Bureau program, noise control treatments were applied in two secondary crushing and screening plants to--

- a. Minimize the impact forces.
- b. Enclose the source.

At a primary crushing plant receiving run-of-mine product, a control booth was installed to enclose the plant operator.

This paper describes how these treatments were applied, the costs associated with the treatments, and the noise reductions achieved.

PRIMARY CRUSHING PLANT

NOISE CONTROL USING OPERATOR CONTROL BOOTH

An extremely cost-effective noise control treatment for stationary plant employees is the construction of a control booth. A booth is not expensive to construct or purchase, can provide noise reductions of 15 to 25 dBA, requires little maintenance, and also helps protect the worker from the weather and other environmental hazards such as dust. The construction or purchase of a booth is straightforward and quite a few have been installed by the industry. In many cases, however, they are not as effective as they could be for the following reasons:

- a. The booth is not large enough.
- b. The booth does not have adequate air conditioning.

c. The booth does not provide adequate field of view for the operator.

d. The booth is not acoustically tight.

e. The booth is not isolated from the plant structure.

For a control booth to be effective, it not only has to reduce the noise, but also has to provide enough comfort so the operator will stay inside the booth during normal plant operation. An operator will not stay in a booth if it is too cramped, too hot, or does not provide adequate visibility.

If a booth is to provide maximum noise reduction, it has to be acoustically tight. Even small leaks can reduce the noise reduction by 10 to 15 dBA.

Booth mounting is also critical. If the booth is mounted directly on the plant structure, the vibration from the plant, which is usually severe, will cause the booth structure to vibrate and radiate noise. If the booth has to be mounted on the structure, it should be mounted on correctly designed vibration isolators. A better alternative, if possible, is to mount the booth on a separate structure that is not in contact with the plant.

During the Bureau program, a booth was specified, purchased, and installed for the operator of a primary crushing plant. The plant uses a 16-ft by 42-in vibrating feeder grizzly and a 32- by 42-in jaw crusher to process run-of-mine product from the quarry. The operator controlled this plant from an open catwalk over the crusher where noise levels averaged 97 dBA.

NOISE REDUCTION AND COST

The 8- by 10-ft (figs. 1-2) booth was purchased for \$4,919. It was mounted on a separate structure that was constructed by quarry personnel using 6-in I-beams. The air-conditioned booth reduced the noise levels at the operator's location to 78 dBA, a 19-dBA reduction. A total

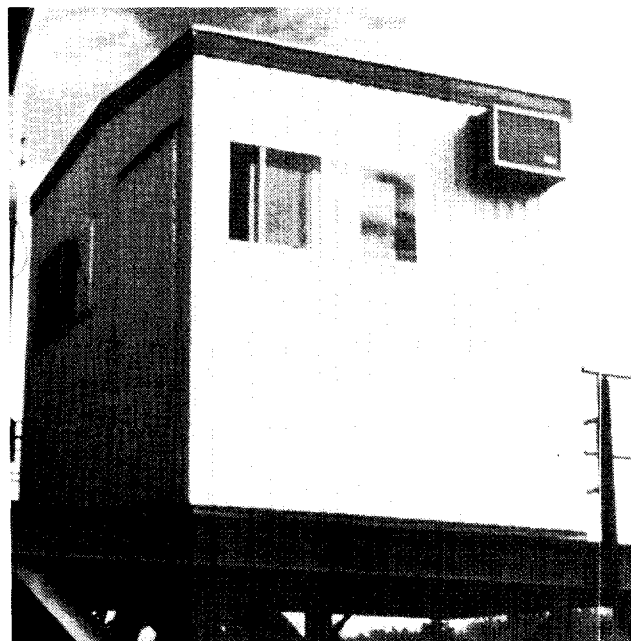


FIGURE 1. - Operator control booth mounted on separate steel support structure.

of 40 h of quarry labor were required to fabricate and install the support structure at the plant and to install controls inside the booth. Details of the physical characteristics of the booth, and octave band sound pressure levels measured inside and outside the booth are included in the final report of the work cited in footnote 3.

SECONDARY CRUSHING AND SCREENING PLANTS

NOISE CONTROL USING RESILIENT MATERIALS TO MINIMIZE IMPACT FORCES

At the two secondary plants addressed during this program, resilient materials were used to minimize the noise produced by the product impacting the plant components. The two plants included

- a. A secondary plant that used a 5- by 14-ft inclined double-deck screen, and a 4-1/4-ft cone crusher.
- b. A secondary plant that used a 5- by 14-ft horizontal double-deck screen, and a 5-ft cone crusher.

Specific treatments at the two plants included

- a. Resilient impact pads for the wall and bottom of the screen feed chute.
- b. Resilient liner for the screen feedbox.
- c. Resilient screen decking.
- d. Resilient liners for the screen side wings.
- e. Resilient screen discharge lip.



FIGURE 2. - Primary crusher operator at his control station inside the booth.

f. Resilient liner for the crusher feed hopper.

g. Resilient liner for the crusher feed cone.

h. Resilient crusher feed plate.

INSTALLATION OF IMPACT PADS ON WALL AND BOTTOM OF SCREEN FEED CHUTE

Typically, screens receive product via a steel chute that is fed by a belt conveyor. Product discharged from the conveyor strikes the wall of the chute, rebounds, and falls to the chute bottom where it discharges to the screen through the feedbox (fig. 3). Noise levels measured near these chutes normally exceed 110 dBA with a coarse product feed.

The recommended noise control treatments for screen feed chutes include

a. A resilient impact pad installed on the chute wall.

b. A resilient impact pad or a product dead bed used in the chute bottom.

These treatments absorb the force of the impact; if properly designed and

installed, they not only reduce noise, but also significantly increase chute life.

The impact pad for the chute wall can be either bolted to the wall or suspended in the chute. Figure 4 shows a profiled surface pad installation. Holes are drilled or burned through the chute wall and the pad is bolted in place. The pad should be the full width of the chute and should extend above and below the impact area.

Proper impact pad selection requires the following information:

a. The type and size of product being processed.

b. The velocity of the product--for the chute wall, the belt speed should be adequate; for the chute bottom, the height of the drop is required.

c. The dimensions of the chute.

d. The angle of product impact.

The last item, angle of impact is particularly critical. The life of resilient

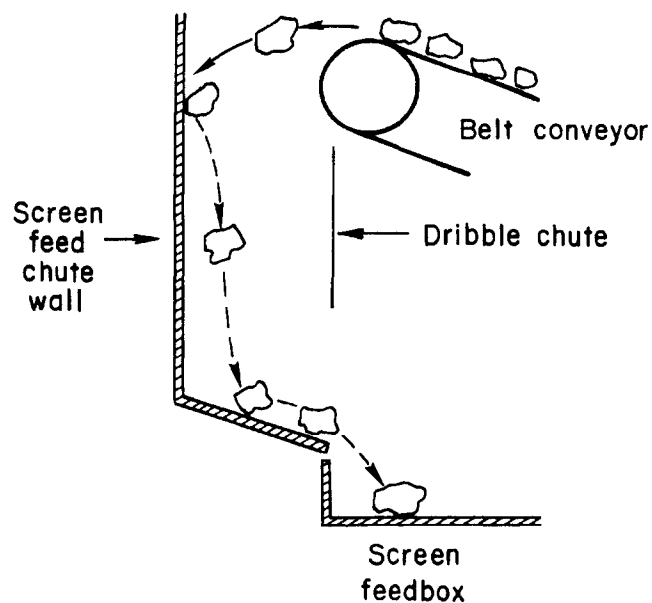


FIGURE 3. - Product feed path from the belt conveyor to the screen feedbox.

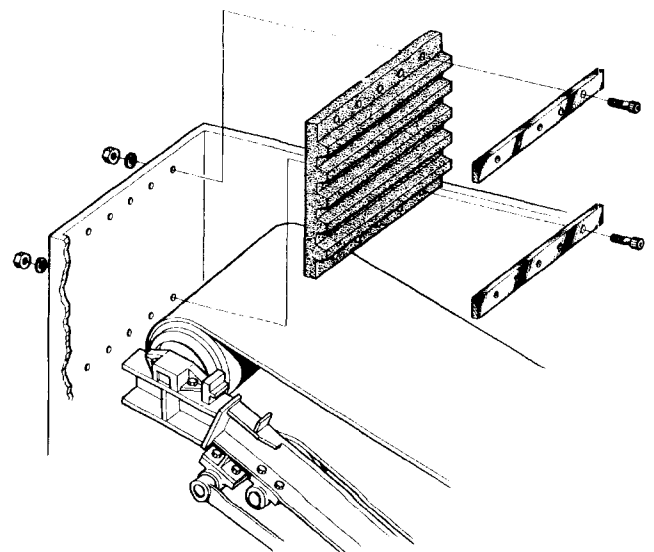


FIGURE 4. - Installation of a profiled surface impact pad on the screen feed chute wall.

pads depends a great deal on the angle of product impact (fig. 5). At impact angles less than 70° the wear rate of a resilient pad will be high. Above 70° the wear rate will be significantly better than steel. A profiled surface, shown in figure 4, can be used to increase the impact angle.

The size, type, and speed of the product are used to determine the required pad thickness. Generally, the larger the product and the higher the velocity, the greater the thickness required to minimize crushing damage to the liner.

An impact pad should also be bolted to the chute bottom as shown in figure 6. The boltholes in the pad should be countersunk by the material manufacturer so the boltheads will be below the pad surface, as shown in figure 7.

The chute bottom can also be protected by creating a dead bed, which is simply a buildup of product at the area of impact. A dead bed is also recommended in combination with a resilient impact pad to

improve the life of the pad and chute bottom.

NOISE CONTROL TREATMENT OF SCREENS

Typically, the product discharged from the feed chute impacts a steel feedbox that is an integral part of the screen. The product then passes over the screening medium which is either punched steel plate or woven wire cloth. The product also impacts the steel side wings or the side-tension rails as it passes along the screen deck. At the discharge end of the screen, the product either passes over or falls onto a steel discharge lip, and then passes into the discharge chute.

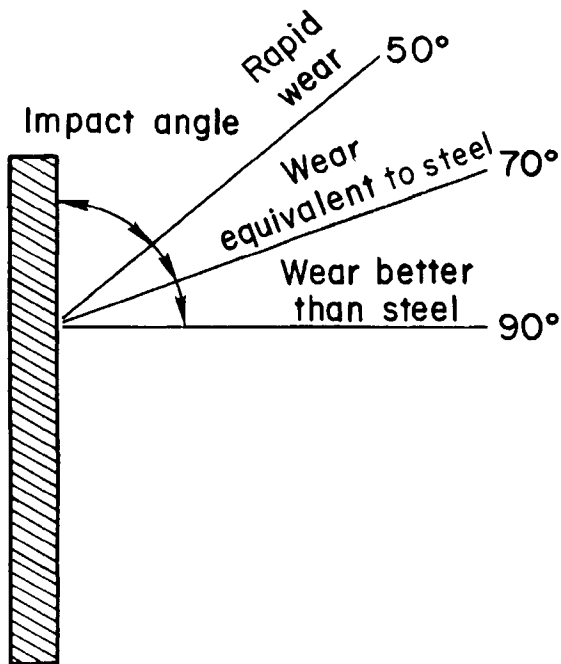


FIGURE 5. - Impact angle of product on resilient pad.

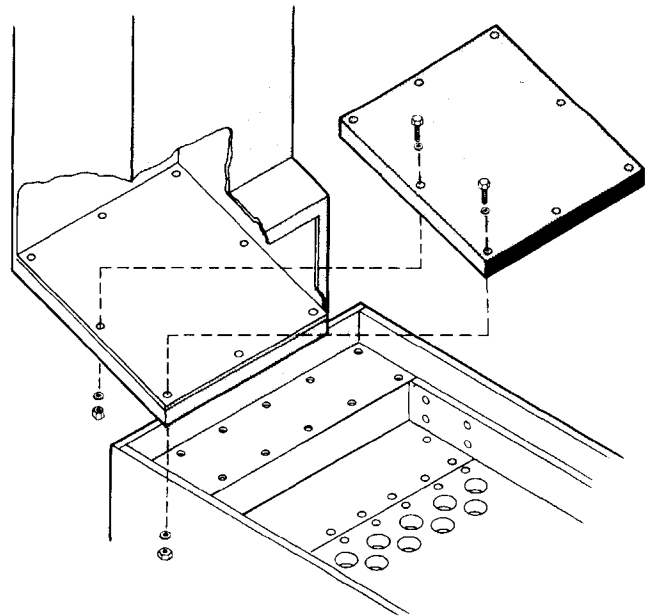


FIGURE 6. - Installation of a resilient impact pad on the bottom of the screen feed chute.

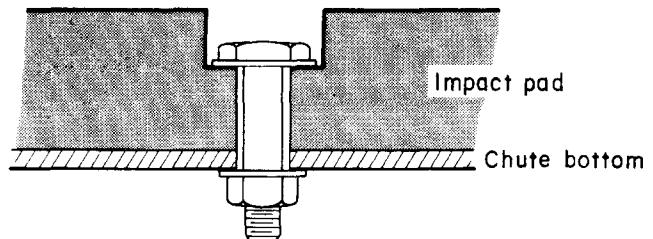


FIGURE 7. - Fastening the impact pad to the bottom of feed chute with countersunk holes in the resilient material.

Noise levels measured beside screens handling coarse material often exceed 105 dBA.

The recommended noise control treatments for screens include

- a. Resilient linings for the screen feedbox.
- b. Resilient screen decking.
- c. Resilient liners on the side wings or side-tension rails.
- d. Resilient liners on the discharge lip and chute.

Most screens are provided with a blank metal panel at the feed end preceded by a feedbox that is often protected by metal wear plates where the product impacts the screen. The blank panel should be replaced by a thicker, blank resilient panel. A resilient impact pad should be installed in the screen feedbox to increase the thickness of the area that is impacted by the product discharge from the feed chute (fig. 8).

The screening medium should be replaced by a resilient deck. When ordering resilient decking, it is important to specify the following information:

- a. Type and size of product being screened.

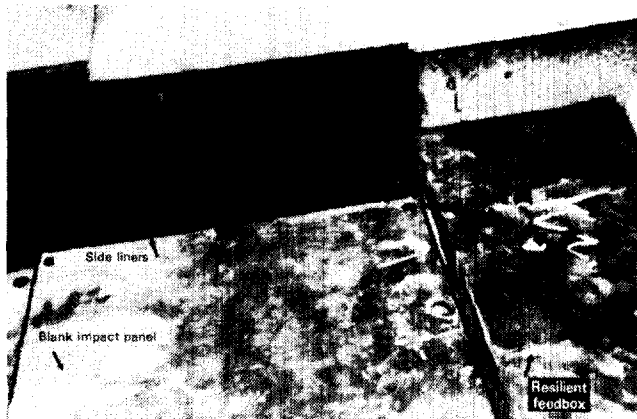


FIGURE 8. - Resilient feedbox with impact pad where feed from the chute strikes the feedbox.

- b. The efficiency of the existing screen deck.

- c. The exact dimensions of the existing deck.

- d. The type of mounting--whether the deck is bolted to the screen frame, or if it is held by side-tension rails.

- e. Type, location, and dimensions of screen support members.

- f. Type and dimensions of holddown clamping.

In selecting a resilient deck, it must be remembered that the use of a resilient cloth may reduce screening efficiency and throughput. This can be caused by the resilient deck having less open area and being thicker than the metal deck. It is also critical to specify exact dimensions because resilient materials are extremely difficult to modify-to-fit in the field.

If the deck is bolted to the screen frame (figs. 9-10), nonperforated areas should be specified over the deck support members. The nonperforations will prevent accumulation of product between the deck and support members, which can cause excessive wear of the frame.

Resilient liners should also be bolted to the screen side wings and discharge lip, as shown in figure 11. The side wing liners should be at least 1 in thick and high enough to protect the side wings from product impact. The discharge lip liner should be the same thickness as the deck. The resilient liners for the sides of the discharge lip (fig. 12) should be thicker than those on the side wings. This will help funnel the screen discharge and prevent product from being jammed between the screen and the screen discharge hopper.

The discharge from a horizontal screen, which feeds a crusher directly by choking the feed down to the opening size of the crusher feed hopper, requires a resilient liner on both the sides and bottom of the

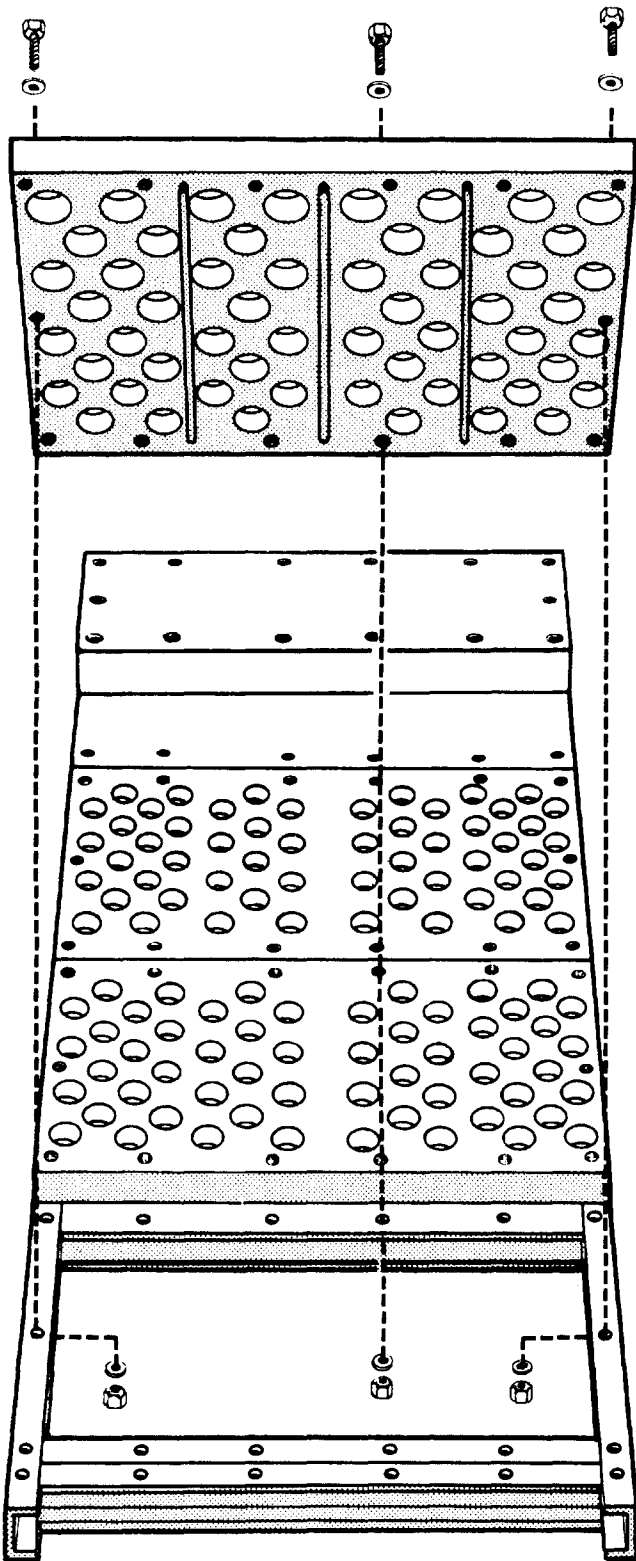


FIGURE 9. - Installation of a bolted resilient screen deck.

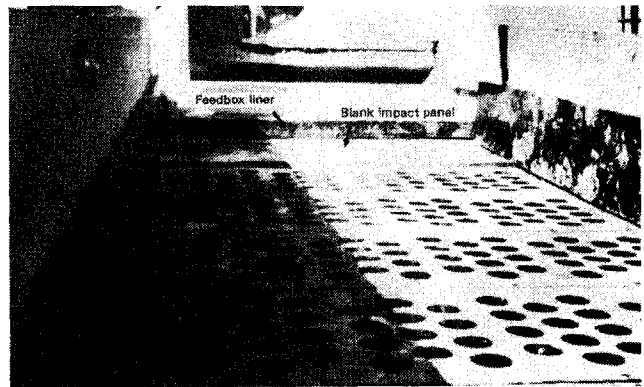


FIGURE 10. - Bolted resilient deck with blank impact panel in the feedbox.

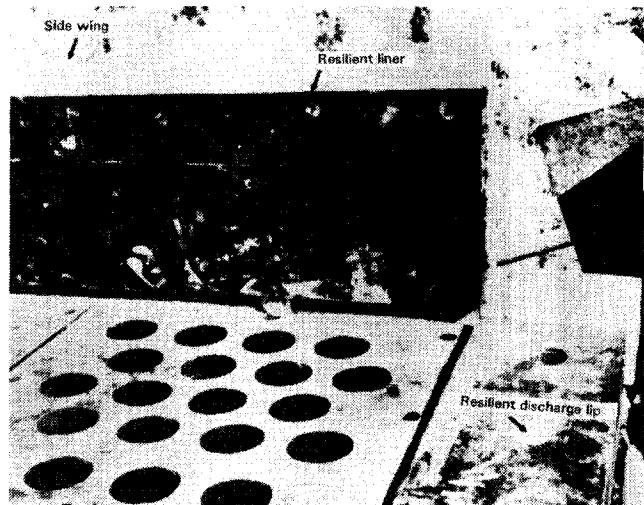


FIGURE 11. - Resilient liners bolted to the screen side wings and discharge lip.

discharge chute (fig. 13). These liners are bolted in place with the boltheads countersunk in the resilient material.

For screens installed using side-tension rails (fig. 14), the rails should also be equipped with resilient impact liners. The liners should be bolted or bonded to the rails. Trowel- or paint-on resilient coatings are not recommended because of their limited durability and effectiveness.

In addition, screen support members require a resilient protective molding (bumper strip) to properly crown the deck and minimize wear (fig. 15). If a center

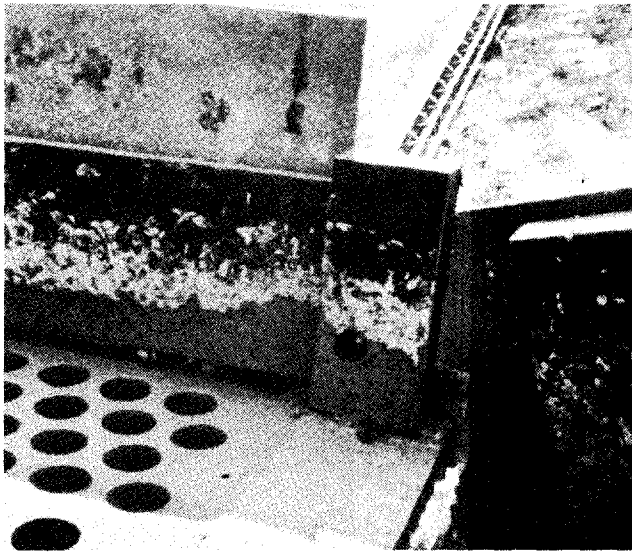


FIGURE 12. - Resilient discharge lip with thickener liners on the sides to funnel the screen discharge.

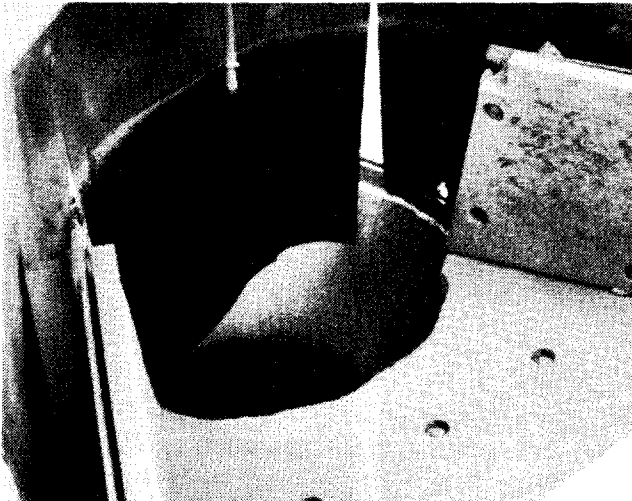


FIGURE 13. - Resilient liner in a screen discharge chute directly feeding a crusher.

clamping bar is used, a resilient molding for the bar should be used. Screen J-hook clamps should use a resilient block or ring to protect the nut and threads.

The use of resilient screen decks can cause operating problems. As previously mentioned, screening efficiency may be decreased, which may require changes to the screen's throw amplitude, speed, and direction. In addition, the product

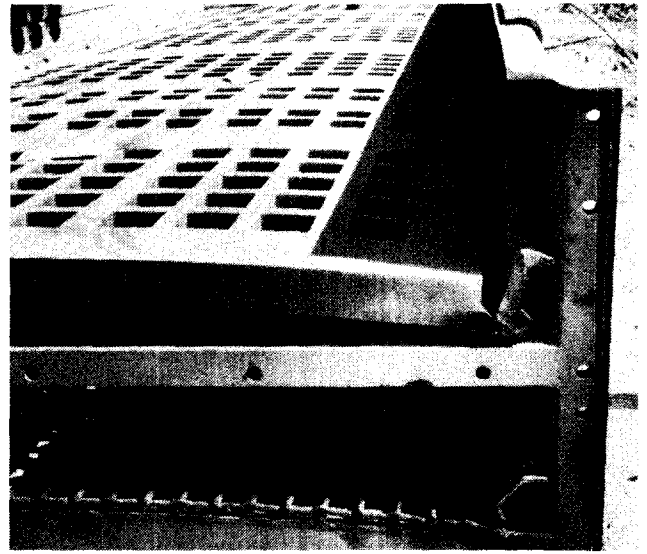


FIGURE 14. - Resilient screen deck with resiliently lined side-tension rails.

tends to bounce more on a resilient deck, especially on an inclined screen receiving coarse product.

The higher bounce can create safety and feed distribution problems. To eliminate these problems, a drag curtain (fig. 16) should be installed over the feed chute discharge. The drag curtain should be made of heavy, abrasion-resistant, resilient material. It should be the full width of the screen and should extend to the end of the blank screen panel. Conveyor belting is not recommended because it wears rapidly and does not have enough mass to retard the product flow.

NOISE CONTROL TREATMENTS FOR A CONE CRUSHER

A typical secondary crushing and screening plant uses a cone crusher to reduce oversized product from the screen. The oversized product is fed to the crusher feed cone from a steel hopper. High noise levels, typically over 110 dBA, are generated when the product impacts the steel crusher components.

The recommended noise control treatments include:

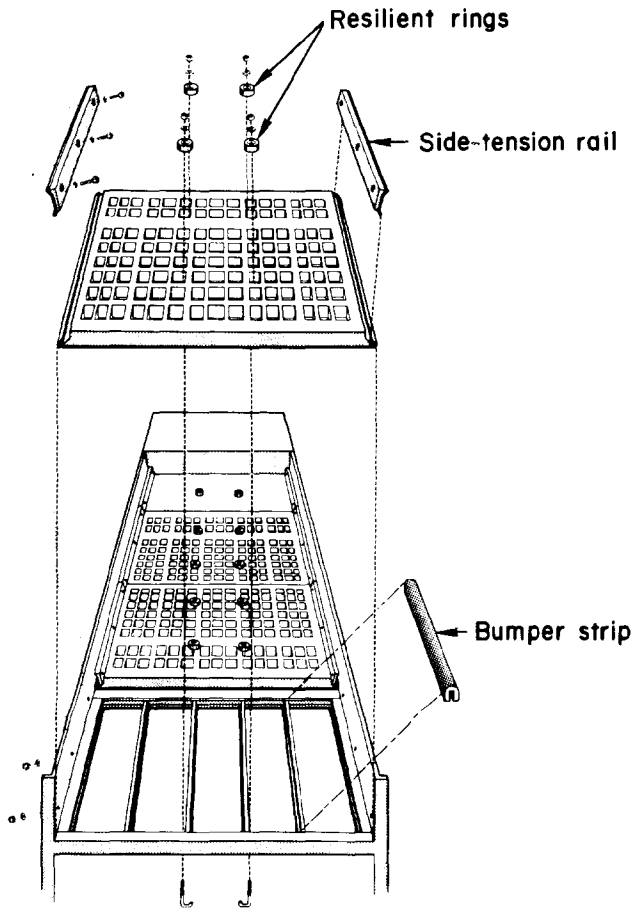


FIGURE 15. - Installation of resilient screen deck using resilient side-tension rails, bumper strips, and blocks on the J-hook clamps.

a. Resilient liners for a surge-type hopper, the feed cone hopper shell, and the feed cone.

b. Resilient feed plate.

c. Barrier curtain around the crusher main frame.

Design of the liner for the crusher feed hopper requires the following information:

a. Size and type of product.

b. Drop height or velocity of the product at impact.

c. Exact hopper dimensions.

d. Angle of impact.

The liner should cover all hopper surfaces impacted by the product, not only during full-load operation, but also during screen startup and shutdown. It is also recommended that the liner (fig. 17) be suspended away from the hopper wall. This will reduce localized crushing forces on the liner and increase liner life.

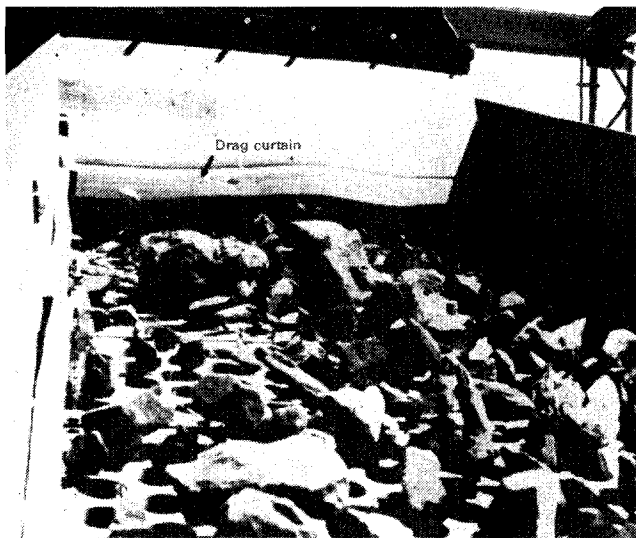


FIGURE 16. - Drag curtain installed on an inclined screen.

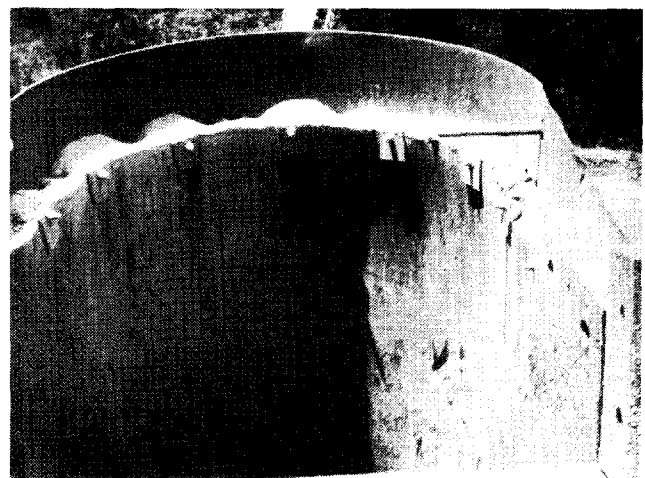


FIGURE 17. - Resilient liner installed in a crusher feed hopper.

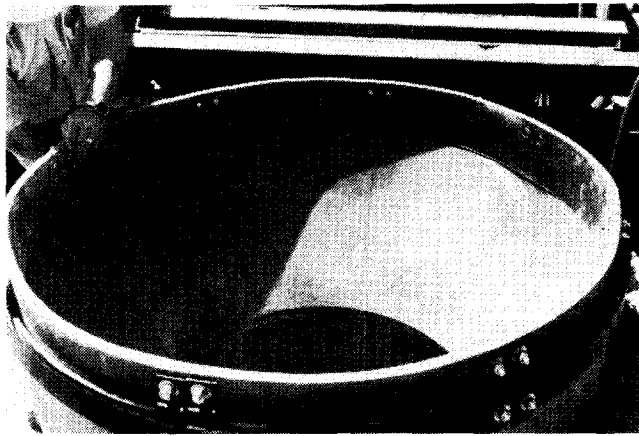


FIGURE 18. - Installation of one-piece resilient crusher feed cone liner.

Resilient liners are also recommended for the crusher feed shell and cone. Care has to be taken in sizing the liner thickness so the thickest liner possible can be used, and yet not cause interference with the material flow through the crusher. Ideally, the shell and cone liners should be a one-piece assembly (fig. 18). This one-piece assembly can be simply inserted over the existing shell and cone or replace the fabricated steel liner assembly.

The lining can also be manufactured as segments for easier handling and attaching to the existing steel liners (fig. 19). This is not recommended, however, because of the possibility of a segment coming loose and passing through the crusher, which can cause significant damage. Another benefit of the full assembly, particularly on crushers without a rotating bowl, is that the liner can be rotated for more even wear.

For cone crushers with a steel feed plate, the plate should be replaced by one manufactured with resilient material (fig. 20). The new feed plate should be cast by the material manufacturer using a mold that matches the steel one. It is recommended, however, that the resilient plate be manufactured thicker and larger in diameter than the steel one to prevent

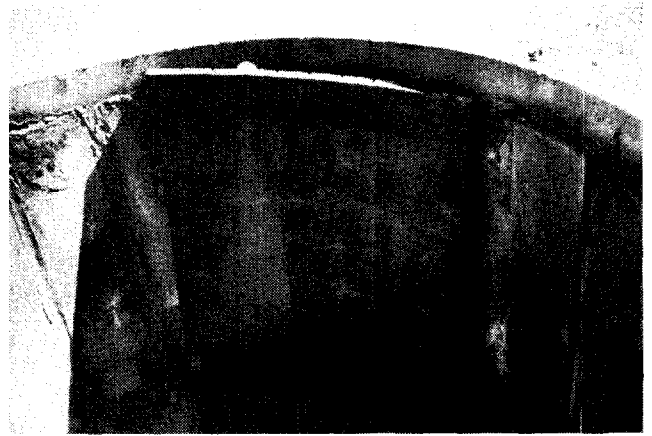


FIGURE 19. - Installation of resilient feed cone liner segments.

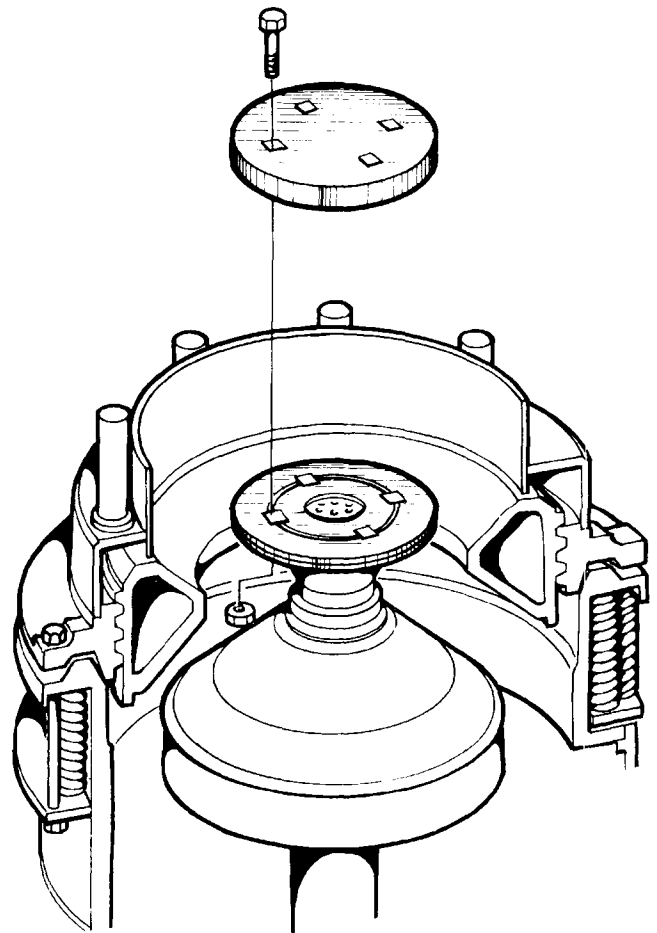


FIGURE 20. - Installation of a resilient crusher feed plate.

premature failure of the material located between the holddown bolts and the outside diameter of the plate. Additionally, the resilient feed plate should be manufactured with an integral steel centering plate to match the machined female fit of the feed distributor or the main shaft nut. Replacing the steel plate with a resilient one will not affect the unbalanced forces of the crusher.

To control the noise radiating from the crushing zone and from product impacting the main frame liner, an acoustical barrier curtain should be installed around the crusher exterior (fig. 21). The curtain should be fabricated from leaded vinyl that has a layer of absorptive material on one side. The material should be purchased wide enough to extend from the adjustment ring to the base of the main frame flange. Grommets should be specified along the top edge of the curtain to provide easy installation on bolts that can be welded to the adjustment ring. By attaching the curtain to the adjustment ring and letting it hang free, the curtain will allow vertical

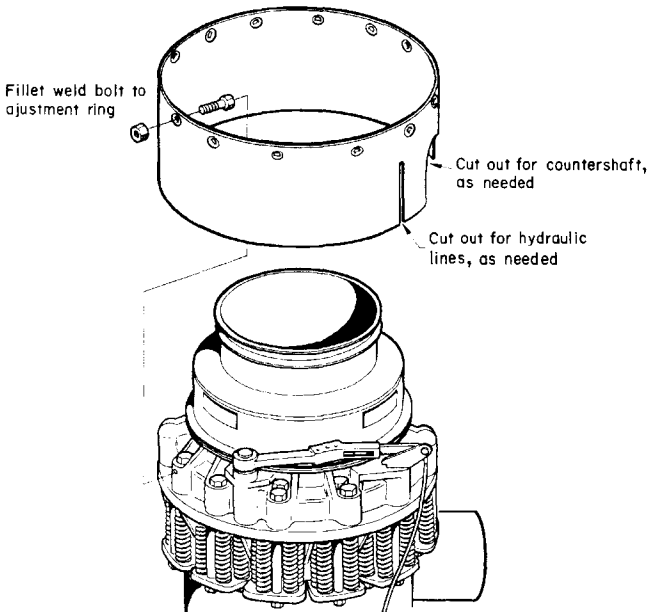


FIGURE 21. - Installation of a barrier curtain around the crusher main frame.

movement when the crusher passes tramp iron and will not interfere with normal crusher servicing. An installed curtain is shown in figure 22. Figure 23 provides octave band spectra of the noise measured at one of the cleanup locations near the crusher treated with the barrier curtain. Additional details regarding

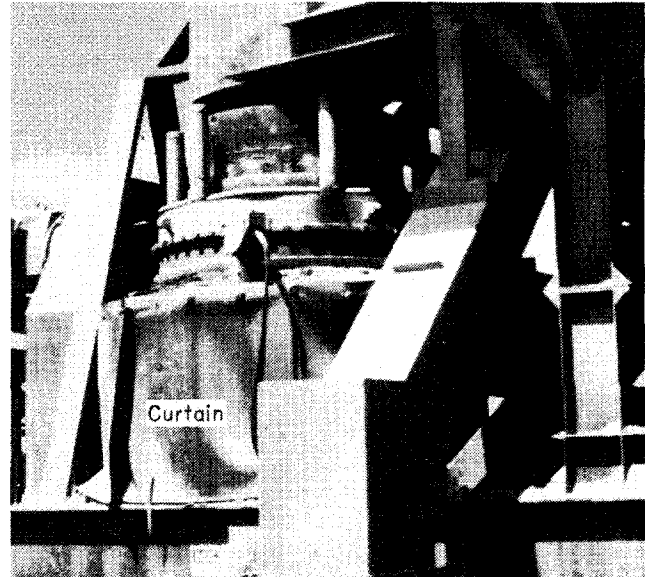


FIGURE 22. - Noise barrier curtain installed around the crusher main frame.

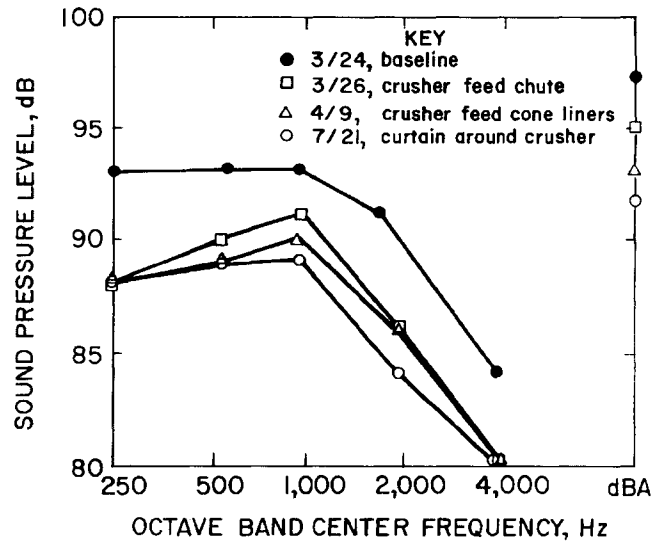


FIGURE 23. - Octave band analysis showing effect of the retrofit treatments, plant B, ground-level cleanup position, near crusher.

installing the noise control modifications on the screen feed chute, screen

decking, screen discharge, and the cone crusher are available from the Bureau.⁴

NOISE REDUCTION AND COST

Noise measured in the near-field of the vibrating screen at both secondary plants showed a reduction of 5 and 8 dBA (113 to 105 and 106 to 101 dBA) for the screen discharges and a reduction of 5 and 9 dBA (106 to 101 and 107 to 98 dBA) for the feed end of the screens. Crusher noise was reduced by 5 dBA (106 to 101 dBA) at one of the two secondary plants.

The installation of the noise control treatments (resilient materials and barrier curtain) reduced the noise levels measured at the usual cleanup or maintenance locations by 4 to 7 dBA (97.5-98 to 93.5-91 dBA) at one of the two secondary plants. Cleanup-maintenance location noise levels were not significantly reduced in the second plant because of the rapid wear of the installed materials.

The costs, in 1981 dollars, for the treatments described for the two

secondary crushing and screening plants treated during this program were \$15,500 (average). Quarry labor required for installation of the modifications averaged 67.5 worker-hours.

At one of the two secondary plants, the retrofit noise control modifications displayed excellent wear characteristics. The rapid wear of the materials at the second plant was due to improper materials being supplied and changing circuit conditions.

⁴Pokora, R. J., T. G. Bobick, and T. L. Muldoon. Retrofit Noise Control Modifications for Crushing and Screening Equipment in the Nonmetallic Mining Industry, An Applications Manual. BuMines IC 8975, 1984, 24 pp.

Information Circular 8986

Noise Control

**Proceedings: Bureau of Mines Technology Transfer
Seminars, Pittsburgh, PA, July 24, 1984,
and Denver, CO, July 26, 1984**

Compiled by Staff, Bureau of Mines



**UNITED STATES DEPARTMENT OF THE INTERIOR
William P. Clark, Secretary**

**BUREAU OF MINES
Robert C. Horton, Director**

Library of Congress Cataloging in Publication Data:

Bureau of Mines Technology Transfer Seminars (1984 :
Pittsburgh, PA, and Denver, CO)

Noise control.

(Information circular / United States Department of the Interior, Bureau of Mines ; 8986)

Includes bibliographies.

Supt. of Docs. no.: I 28.27:8986.

1. Noise control--Congresses. 2. Mine safety--Congresses. I. United States. Bureau of Mines. II. Title. III. Series: Information Circular (United States. Bureau of Mines) ; 8986.

TN295.U4 622s [622'.4] 84-600 194