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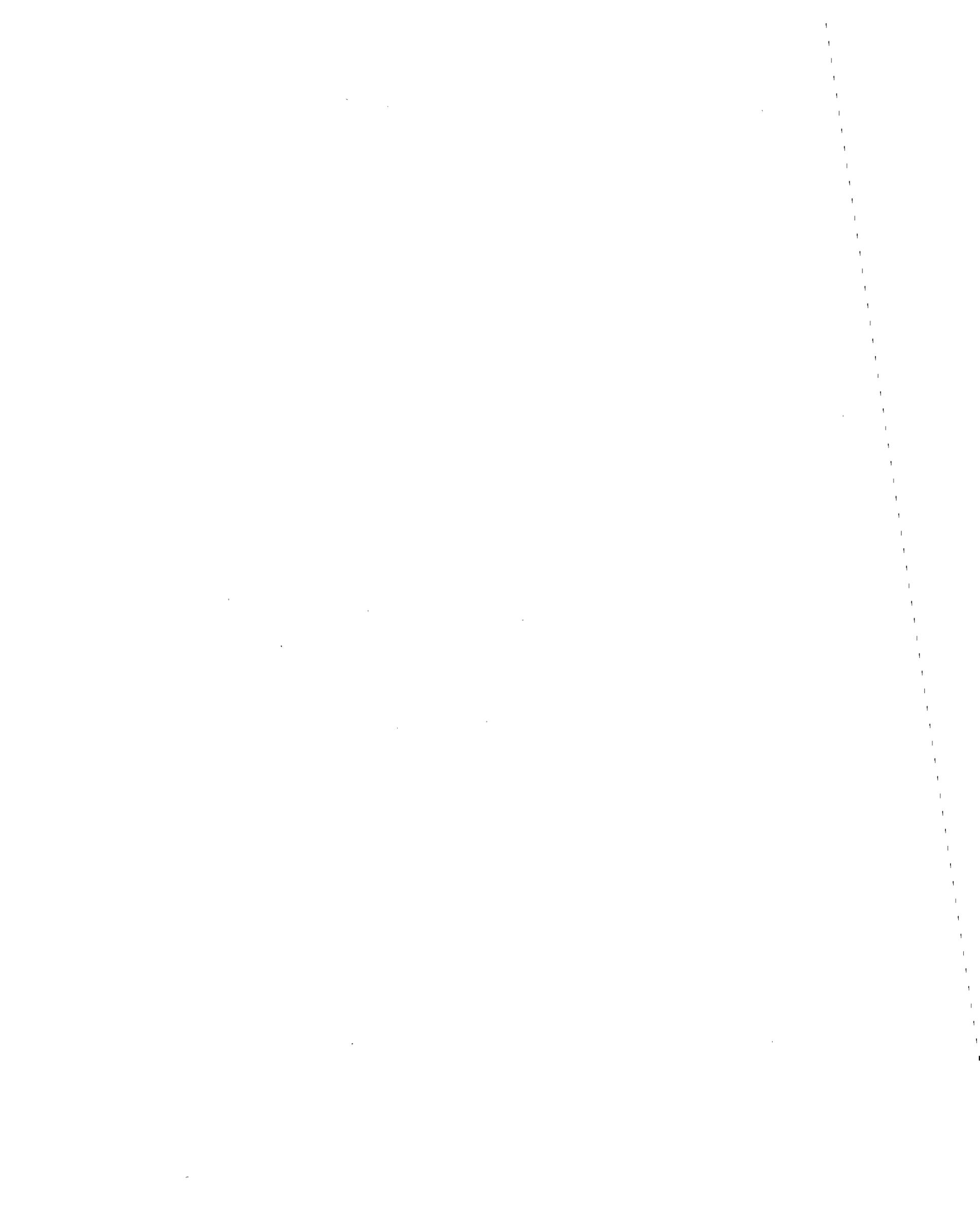
Retrofit Noise Control Modifications for Crushing and Screening Equipment in the Nonmetallic Mining Industry, An Applications Manual

By R. J. Pokora, T. G. Bobick, and T. L. Muldoon



UNITED STATES DEPARTMENT OF THE INTERIOR

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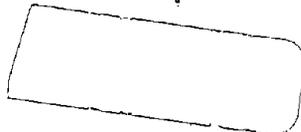
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<p>This Bureau of Mines report is an applications manual that can be used by the nonmetallic mining industry for guidance in installing noise control materials into crushing and screening plants. These noise control modifications were installed and successfully tested at three operating quarries. This report identifies the major noise sources that can be encountered in crushing and screening plants, and discusses the applicable noise control materials and techniques that a plant operator can utilize on a retrofit basis to reduce equipment noise.</p>			
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CONTENTS

	<u>Page</u>
Abstract.....	1
Introduction.....	2
Federal noise regulations.....	2
Background.....	2
Noise source identification.....	3
Noise control treatments.....	4
Noise control treatment costs.....	4
Manual organization and content.....	4
Noise control treatment of the screen feed chute.....	5
Design and selection of resilient impact pads.....	6
Installation of the chute wall impact pad.....	7
Installation of an impact pad or dead bed in the chute bottom.....	8
Noise control treatment of screens.....	9
Design and selection of noise control treatments for screens.....	9
Installation of noise control treatments for screens.....	11
Noise control treatments for a cone crusher.....	17
Design and selection of noise control treatments for cone crushers.....	17
Installation of noise control treatments for crushers.....	18
Noise control using an operator control booth.....	21
General selection guidelines.....	21
General construction guidelines.....	22
Typical booth installation.....	22
Summary and conclusions.....	24

ILLUSTRATIONS

1. Product feed path from the belt conveyor to the screen feedbox.....	5
2. Effect of impact angle of product on resilient pad life.....	6
3. Use of a profiled impact pad to provide a better impact angle for increased wear life.....	6
4. Installation of a profiled-surface impact pad.....	7
5. Installation of a resilient impact pad may cause a change in product rebound.....	7
6. Installation of a resilient impact pad on the bottom of the screen feed chute.....	8
7. Impact pad fastened to the bottom of feed chute with countersunk holes for protection of boltheads.....	8
8. Installation of a dam to create a dead bed on the chute bottom.....	9
9. Combination of a resilient impact pad and dead bed in the bottom of a secondary screen feed chute.....	9
10. Cross section of typical resilient protection for sizing screens.....	11
11. Installation of a bolted resilient screen deck and blank impact panel.....	12
12. Bolted resilient deck with blank panel in the feedbox.....	12
13. Resilient feedbox with impact pad where product from the chute strikes the feedbox.....	12
14. Installation of resilient side wing liners.....	13
15. Resilient liners bolted to screen side wings.....	13
16. Installation of a resilient screen deck using side-tension rails.....	13
17. Resilient screen deck with resiliently lined, side-tension rails.....	13
18. Resilient deck installed on a horizontal screen using resiliently lined, side-tension rails and J-hook clamps.....	14

ILLUSTRATIONS--Continued

	<u>Page</u>
19. Treatment of the screen discharge lip.....	14
20. Resilient discharge lip with thicker side liners to funnel the screen discharge.....	14
21. Installation of resilient liners on a screen discharge chute.....	15
22. Resilient liner in a screen discharge chute directly feeding a crusher....	15
23. Installation of a drag curtain over the feed chute discharge.....	16
24. Drag curtain installed on an inclined screen.....	16
25. Resilient liner installed in the crusher feed hopper.....	18
26. Installation of a resilient crusher feed cone shell liner.....	19
27. Installation of a one-piece resilient crusher feed cone liner.....	19
28. Installation of resilient feed cone liner segments.....	20
29. Installation of a resilient crusher feed plate.....	20
30. Installation of a molded resilient pad for the mantle hold-down cap.....	20
31. Installation of a barrier curtain around the crusher main frame.....	21
32. Noise barrier curtain installed around the crusher main frame.....	21
33. Basic control booth wall construction.....	22
34. View of a primary crushing plant with an operator control booth.....	23
35. Operator control booth mounted on separate steel support structure.....	23
36. Separate control booth support structure constructed by quarry personnel..	23
37. Primary crusher operator at the control station inside the booth.....	23

TABLE

1. Permissible noise exposures.....	2
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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT			
dB	decibel	in	inch
dBA	decibel, A-weighted	pct	percent
ft	foot	ton/h	ton per hour
h	hour		

RETROFIT NOISE CONTROL MODIFICATIONS FOR CRUSHING AND SCREENING
EQUIPMENT IN THE NONMETALLIC MINING INDUSTRY,
AN APPLICATIONS MANUAL

By R. J. Pokora,¹ T. G. Bobick,² and T. L. Muldoon³

ABSTRACT

This Bureau of Mines report is an applications manual that can be used by the nonmetallic mining industry for guidance in installing noise control materials into crushing and screening plants. These noise control modifications were installed and successfully tested at three operating quarries. This report identifies the major noise sources that can be encountered in crushing and screening plants, and discusses the applicable noise control materials and techniques that a plant operator can utilize on a retrofit basis to reduce equipment noise.

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INTRODUCTION

FEDERAL NOISE REGULATIONS

Noise levels generated by the crushing and screening of nonmetallic minerals are regulated under 30 CFR, Part 56--Safety and Health Standards--Sand, Gravel, and Crushed Stone Operations. Section 56.5-50 states:

Mandatory. (a) No employee shall be permitted an exposure to noise in excess of that specified in table 1.

TABLE 1. - Permissible noise exposures

<u>Duration per day, hours of exposure</u>	<u>Sound level, dBA, slow response</u>
8.....	90
6.....	92
4.....	95
3.....	97
2.....	100
1-1/2.....	102
1.....	105
1/2.....	110
1/4 or less.....	115

NOTE.--No exposure shall exceed 115 dBA. Impact or impulsive noises shall not exceed 140 dB, peak sound pressure level.

NOTE: When the daily noise exposure is composed of two or more periods of noise exposure at different levels, their combined effect shall be considered rather than the individual effect of each.

If the sum

$$(C_1/T_1) + (C_2/T_2) + \dots + (C_n/T_n)$$

exceeds unity, then the mixed exposure shall be considered to exceed the permissible exposure. C_n indicates the total time of exposure at a specified noise level, and T_n indicates the total time of exposure

permitted at that level. Interpolation between tabulated values may be determined by the following formula:

$$\text{Log } T = 6.322 - 0.0602 \text{ SL,}$$

where T is the time in hours and SL is the sound level in dBA.

(b) When employees' exposure exceeds that listed in table 1, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce exposure to within permissible levels, personal protection equipment shall be provided and used to reduce sound levels to within the levels of the table.

Enforcement of the standards has shown that an acute noise exposure problem exists in the sand and gravel and crushed stone industries.

BACKGROUND

In 1981, a Bureau of Mines study⁴ of the noise exposures of workers in crushing and screening plants concluded that plant operators and plant cleanup personnel can have full-shift noise exposures that range from three to four times that allowed by the standard. The study also included an analysis of the major noise sources that contribute to the overexposure problem.

As part of this same research program, retrofit noise control treatments for the major sources were designed, installed, and evaluated in three crushing and screening plants. The three plants,

⁴Pokora, 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.

which were selected from a series of eight surveyed, included--

- A primary crushing plant that received run-of-mine product from the quarry. The plant used a 16-ft by 42-in vibrating feeder grizzly and a 32- by 42-in jaw crusher.

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

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

All three plants had a capacity of 200 to 300 ton/h.

The noise control treatments described in this manual were developed for this program and are, therefore, somewhat specific to these sizes and types of plants. The basic treatments, however, with some modifications, are applicable to all crushing and screening plants.

NOISE SOURCE IDENTIFICATION

The first step in any noise control effort is to determine what noise sources are contributing most significantly to the overexposure problem. Noise level measurements, coupled with on-site observations, identified the following major noise sources as those that could be treated in the field:

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.

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

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.

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 media and impacts a discharge chute, transfer conveyor, or another screen deck.

Crusher feed hopper or chute.--The feed to the crusher impacts a cylindrical-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 material to build up and, therefore, attenuate the noise.

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.

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.

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.

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.

NOISE CONTROL TREATMENTS

The noise associated with each of the sources is usually generated by the impact of the product on the steel components. The impact forces cause the components to resonate, creating airborne noise.

Noise control treatments can be applied to--

- Minimize the impact forces.
- Damp a vibrating steel component.
- Enclose the source to block the airborne noise.
- Enclose the worker to block the airborne noise.

At the two secondary plants addressed during the Bureau program, resilient materials were applied at certain locations to minimize the noise produced by product impact on the structure. Specific treatments included--

- Resilient impact pads installed on the wall and bottom of the screen feed chute.
- Resilient liner for the screen feed-box.
- Resilient screen decking.
- Resilient liners for the screen side wings.
- Resilient screen discharge lip.
- Resilient liner for the crusher feed hopper.
- Resilient liner for the crusher feed cone.
- Resilient crusher feed plate(s).

In addition, an acoustical curtain was used to enclose the crusher shell to block the airborne noise radiating from

the main frame. Noise measurements at plant operating positions and cleanup areas showed noise reductions of 4 to 7 dBA. These reductions, which approximately double the allowable exposure times in these work areas, should reduce the full-shift noise exposures of cleanup and maintenance personnel to within those specified by Federal regulations.

At the primary crushing plant, an operating booth was manufactured and installed to enclose the crusher operator. Noise measurements showed a reduction of approximately 20 dBA resulting in noise levels in the booth of less than 80 dBA.

NOISE CONTROL TREATMENT COSTS

The costs, in 1981 dollars, for the treatments described for the two secondary plants averaged \$15,500 (\$14,003 and \$17,085) for materials. Quarry labor required for installation of the treatments averaged 67.5 work-hours (66 and 69 h). The booth, purchased commercially, cost \$4,919 (1981) and required 40 work-hours for installation.

These costs are for purchasing and installing materials manufactured specifically for the three plants treated in this program. They are a good estimate for the costs of treating similar-sized plants using commercially available material and plant labor for installation. Costs will probably be higher for larger-sized plants, or for treatments installed by an outside firm.

MANUAL ORGANIZATION AND CONTENT

This manual is primarily intended as a general guide for the design, selection, and installation of noise control treatments for crushing and screening plants. Most of the treatments discussed have been installed in two secondary crushing and screening plants, and the drawings and photos are oriented toward that type of plant. The treatments, however, are applicable to other plant sizes and types.

The main portion of this manual divides the plant into major components for discussion. The discussion for each component covers--

- How the noise is produced.
- Typical noise levels generated.
- The design and selection of noise control treatments.
- How the noise control treatments are installed.
- Any potential problems created by the treatments.

The manual also includes a section on the design, fabrication, and installation of control booths for protecting the plant operators.

NOISE CONTROL TREATMENT OF THE SCREEN FEED CHUTE

Typically, screens receive product to be processed via a steel chute that is fed by a belt conveyor. Product discharged from the conveyor strikes the sides and wall of the chute, rebounds, and falls to the chute bottom where it discharges to the screen through the feedbox (fig. 1). Noise levels measured adjacent to these chutes normally exceed 110 dBA with a coarse product feed. Noise levels at normal operating positions near these chutes approach 100 dBA.

The recommended noise control treatments include--

- Installing a resilient impact pad on the chute wall and/or sides.
- Using a resilient impact pad or a product dead bed in the chute bottom.

The purpose of these treatments is to absorb the force of the product impact, thus reducing the amount of energy transferred to the steel chute. If properly

The manual is not plant specific. It does not specify materials by type, and does not specify dimensions. There are a number of well-known manufacturers of the types of materials recommended in this manual. It is not the Bureau's intent to make specific recommendations; the appropriate noise control treatment will depend on the actual operating conditions encountered and the noise levels measured at a plant. Thus, it is not possible to state exact dimensions or specific material requirements. The manual, however, does provide general design considerations, and does discuss what information must be provided by the plant operator to a noise-control material manufacturer to ensure proper material design.

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

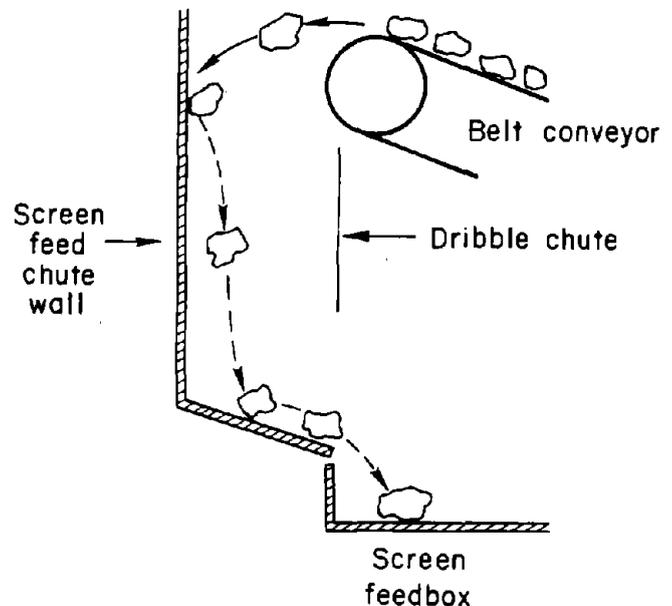


FIGURE 1. - Product feed path from the belt conveyor to the screen feed box.

DESIGN AND SELECTION OF RESILIENT IMPACT PADS

Proper design of impact pads for maximum noise reduction and minimum wear requires designing for--

- Product type.
- Product size.
- Product impact angle.
- Product velocity.

The angle that the product strikes an impact pad will determine the life of the pad (see figure 2). Impact angles of less than 50° will result in rapid wear and less life than steel. Impact angles between 50° and 70° will yield a wear life comparable to steel. Angles greater than 70° and less than 90° are considered optimum. If the impact angle is 70° or above, the impact pad can be a flat sheet. If the angle is less than 70° , a profiled surface that provides a greater impact angle is recommended (fig. 3).

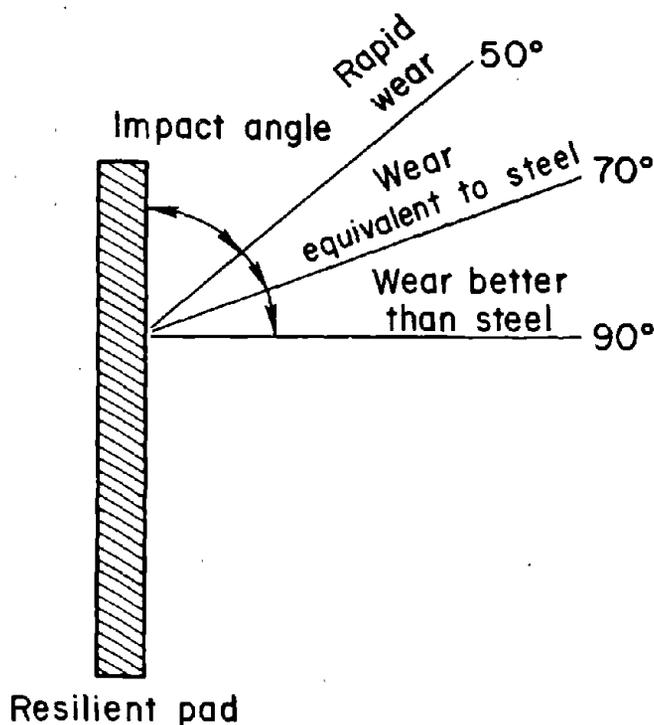


FIGURE 2. - Effect of impact angle of product on resilient pad life.

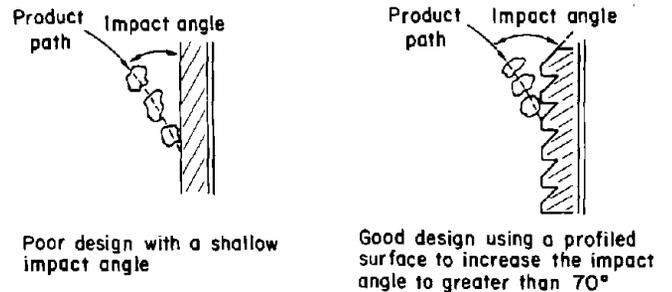


FIGURE 3. - Use of a profiled impact pad to provide a better impact angle for increased wear life.

The thickness of the pad must be sufficient to minimize crushing damage to the liner. The required thickness depends upon both the size of the product striking the pad and the velocity of the product at impact. Generally, the larger the product and the higher the velocity, the greater the thickness of material that is required for optimum wear. This increased thickness, however, must be balanced against available space within the chute. In small chutes, the rubber thickness could interfere with the head pulley or belt scraper and could retard product flow out of the chute.

The type and the mechanical properties of resilient materials (selected for the impact pads) are site specific, and depend primarily upon the size, shape, and type of product being processed.

Selection of the material, in terms of its hardness, thickness, and proper surface profile, should be the responsibility of the material manufacturer. The user, however, must provide the following information for proper impact pad selection:

Type of product being processed.

Size of product being processed.

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

Dimensions of the chute.

Angle of product impact.

Relative position of the head pulley, belt cleaner, and dribble chute.

Representatives of companies of any potentially applicable resilient materials will definitely have to visit the quarry operations before specifying any products. This may be the only opportunity for the material manufacturer and the quarry operator to actively discuss the implied and explicit warranties of the resilient materials, the extent of the required labor needed for material installation, and whose responsibility it will be to make field modifications to any improperly fitting resilient products.

INSTALLATION OF THE CHUTE WALL IMPACT PAD

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. Corresponding holes are drilled through the impact pad. Drilled steel bars should be placed between the resilient pad and boltheads for better support. The pad should be the full width of the chute wall and should extend both above and below the impact area.

The pad can also be suspended in the chute using cables or steel straps that secure it to the chute side walls. If

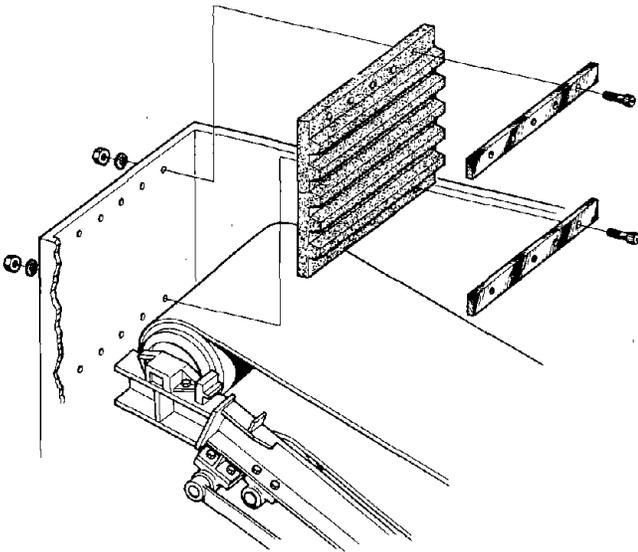


FIGURE 4. • Installation of a profiled-surface impact pad.

space permits, the pad can be suspended away from the chute wall, allowing it to swing freely. This will help reduce crushing forces on the pad and should increase its life. Care must be taken, however, to insure that the pad does not swing into the conveyor belt head pulley when the feed is shut down and the product flow into the pad stops.

Once the pad is installed, the clearance between it and the head pulley should be checked regularly to ensure that the pad does not interfere with the pulley or belt scrapers. Additionally, the flow of the product in the chute should be observed. Using a resilient impact pad can change the angle at which the material rebounds from the chute wall (shown in figure 5). Depending on the chute depth, a change in angle might create another impact point before the product reaches the chute bottom; this may then require an impact pad for the dribble chute. An important caution is that the installation of impact pads may create material handling and/or equipment problems if the conveyor speeds are too high, if incorrect idlers are used, or if insufficient clearances exist around the conveyor. Specifications from the Conveyor Equipment Manufacturer's Association for the design and installation of conveyors must be followed. Questions concerning proper design and fine tuning a conveyor system are best answered by the manufacturer. If dust control sprays are used in the chute, then adequate clearance has to be provided before installing the impact pad. The water

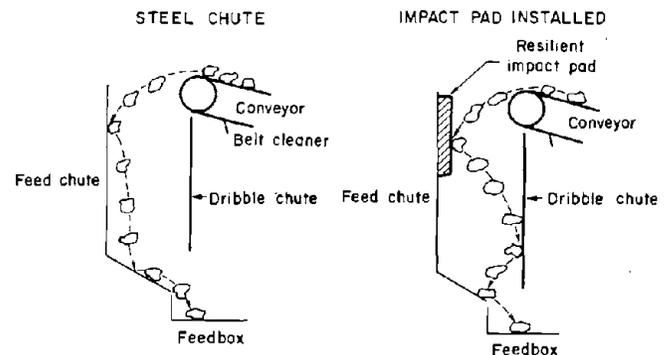


FIGURE 5. • Installation of a resilient impact pad may cause a change in product rebound.

sprays will have to be readjusted after restarting the circuit to accommodate any change in the rebound of the product.

INSTALLATION OF AN IMPACT PAD OR DEAD BED IN THE CHUTE BOTTOM

An impact pad should also be bolted to the bottom of the feed chute, as shown in figure 6. Holes can be drilled or burned through the chute after marking it to correspond to those that are drilled through the pad(s). The holes 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 pad should cover the entire chute bottom.

Most resilient materials have a higher coefficient of sliding friction than steel. Installation of the pad, therefore, may tend to retard the product flow out of the chute. If product flow is unsatisfactory, the angle of the chute bottom may have to be increased to overcome the increased friction of the pad.

The chute bottom can also be modified by creating a dead bed. A dead bed is nothing more than a buildup of product at the area of impact. A dead bed is created by installing a dam at the discharge end of the chute bottom (as shown in figure 8) to retard the product flow. The dam can be made from resilient material or channel iron, should be bolted to the chute bottom, and should extend the entire width of the chute. The height of the dam will depend on the angle of repose of the product flowing through the chute and the angle of the chute bottom. It must be high enough to create a layer of product that covers the entire chute bottom. A dead bed is also recommended

in combination with a resilient impact pad to improve the life of the pad. A combination of an impact pad and dead bed installed in a chute bottom is shown in figure 9; the impact pad is covered by the dead bed, however, and is not visible in the figure.

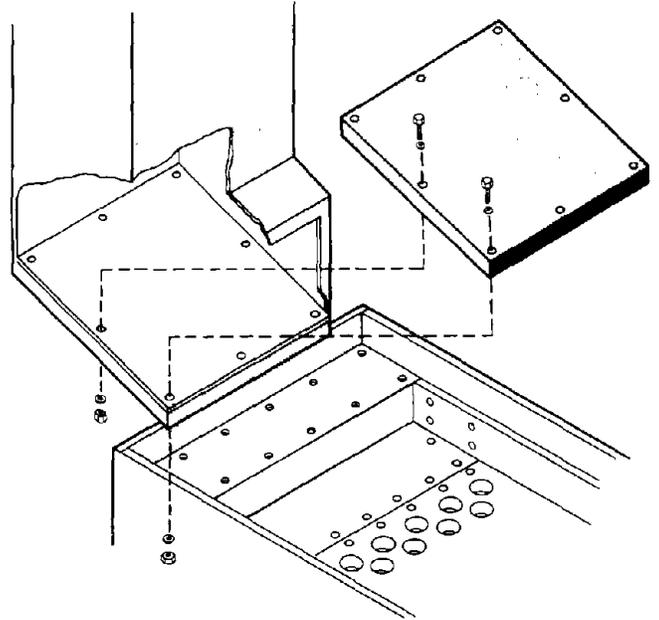


FIGURE 6, - Installation of a resilient impact pad on the bottom of the screen feed chute.

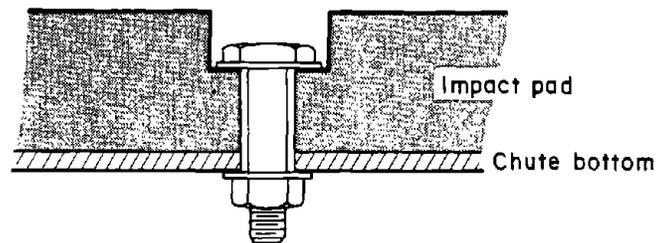


FIGURE 7, - Impact pad fastened to the bottom of feed chute with countersunk holes for protection of boltheads.

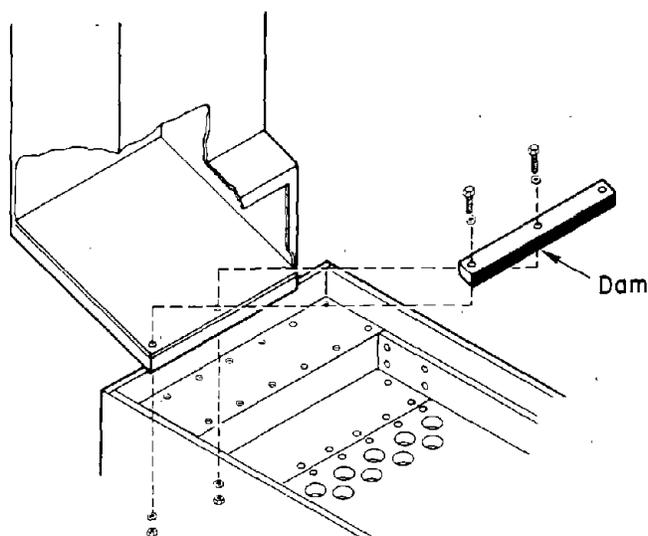


FIGURE 8. • Installation of a dam to create a dead bed on the chute bottom.

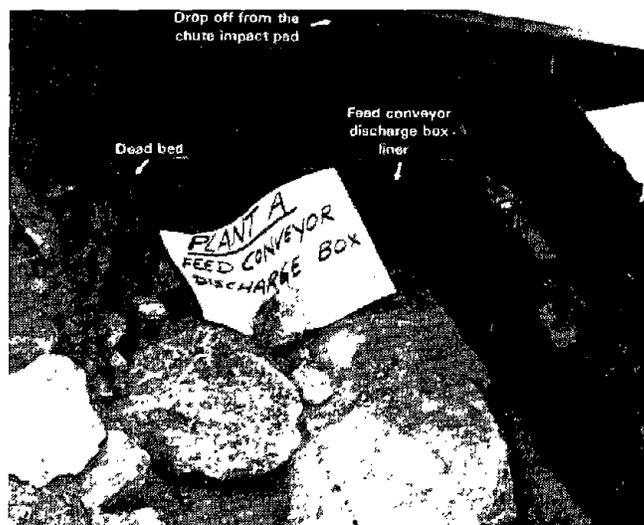


FIGURE 9. • Combination of a resilient impact pad and deadbed in the bottom of a secondary screen feed chute.

NOISE CONTROL TREATMENT OF SCREENS

Typically, the product discharged from the screen 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. Depending on the discharge trajectory, the oversize product either passes over or falls onto a steel discharge lip. Most screens are furnished with either steel side wings or with steel side-tension rails that are also impacted as the product passes along the deck.

High noise levels are generated by the product impacting on the steel feedbox, on the deck, against the side wings or tension rails, and on the steel discharge lip. Noise levels measured beside screens handling coarse material often exceed 105 dBA.

The recommended noise control treatments include--

- Resilient linings for the screen feedbox.
- Resilient screen decking.

- Resilient side wing liners, or resilient material liners on the side-tension rails.
- Resilient screen discharge lip.

DESIGN AND SELECTION OF NOISE CONTROL TREATMENTS FOR SCREENS

Most screen manufacturers do not recommend discharging product directly onto the perforated part of the screen deck. This is especially true for screens handling coarse product with a large drop height from the feed chute. These 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 from the feed chute. The back and sides of the screen feedbox should also be treated with a resilient liner.

The screening medium (punched plate or woven wire) should be replaced with a resilient deck. In selecting the resilient deck, it must be remembered that the use of a resilient cloth may reduce screening efficiency and throughput. This reduction can be caused by--

- Less percent open area for the same deck area.
- The resilient cloth (being thicker to maintain strength) may cause blinding of the screening medium, thus further reducing the percent open area in the deck.
- Screening is normally accomplished in the initial one-third of the deck; if a screen is marginally sized for a specific capacity, then arbitrarily replacing a perforated panel with a blank one will also reduce the screening efficiency.

The actual thickness of the cloth depends upon the maximum feed size and the thickness of the bed depth. The cloth, however, should not be thicker than the size of the openings in the deck.

When ordering resilient decking, it is important to specify the following information to the deck manufacturer:

Use of the screen in the circuit (sizing, scalping, transferring, etc.).

The efficiency of the screen (i.e., the percent near size and undersize material contained in the oversize product).

Type and size of product being screened.

Dimensions of the existing deck.

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

Type, location, and dimensions of screen support members.

Type and dimensions of holddown clamping.

Resilient materials are extremely difficult to "modify-to-fit" in the field; thus, exact equipment dimensions must be provided to the resilient material supplier.

If the deck is bolted to the screen frame, nonperforated areas should be specified over the deck support members. The nonperforated areas will protect the support members and prevent accumulation of product between the deck and supports, which can cause excessive wear of the frame. If the screen has steel side wings, resilient liners that are at least 1 in thick and high enough to protect the side wings from product impact should be specified.

If the screen cloth is attached using side-tension rails, the type and size of rail have to be specified. Most manufacturers of resilient decks supply side-tension rails equipped with a resilient impact liner that is bonded or bolted to the rails. Trowel- or paint-on resilient coatings have had limited durability, and their use is not recommended.

As mentioned, the type and size of support members have to be specified. Support members require a resilient protective molding (shown in figure 10A), called a bumper strip, to minimize deck wear and properly crown the deck. The type of deck clamping also has to be specified. If the screen uses a center clamping bar, a resilient molding for the bar (fig. 10B) is available from the manufacturers. Screen clamping with J-hooks should use a resilient block or ring (fig. 10C) to protect the nut and threads on each hook. These blocks or rings are also available from the deck manufacturer. The Bureau recommends ordering extra clamping hardware at the outset because any discontinuity on the screen deck surface appears to accelerate the wear on the clamping device.

The discharge lip and sides should also be lined with resilient material. For a straight lip discharge, the thickness of the bottom pad should be the same as the thickness of the deck. The resilient

INSTALLATION OF NOISE CONTROL TREATMENTS FOR SCREENS

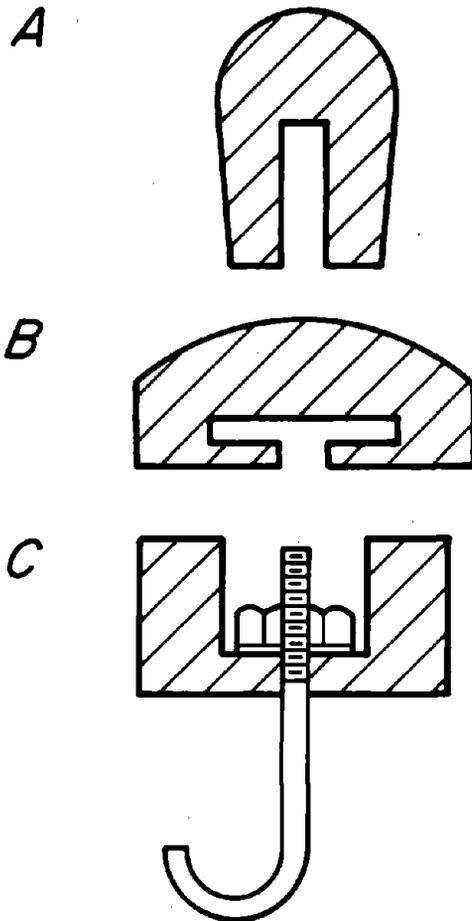


FIGURE 10. • Cross section of typical resilient protection for sizing screens. A, Molding (bumper strip) for support members; B, molding for a center bar clamp; C, block or ring for a J-hook clamp.

liners for the sides of the lip should be thicker than those on the side wings. Increasing the thickness of the side lip liner will funnel the screen discharge and help prevent product from being jammed between the screen and the screen discharge hopper. A horizontal screen discharge, 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 discharge chute. To minimize installation problems, the exact size and shape of the chute bottom and sides should be specified. Most resilient liners that are used in coarse screening are reinforced with steel plate or woven wire; thus, modifying them in the field during installation is extremely difficult and time consuming.

Treating the screen feedbox with a resilient liner, installing an impact pad or plate, and replacing the perforated metal (or woven wire) deck with resilient decking is fairly straightforward, provided the measurements were obtained carefully. Installation of a resilient deck that is to be bolted in place (fig. 11) requires--

- Removing the steel screen deck and blank feedbox panel.
- Carefully measuring and locating bolthole locations on the resilient deck and blank feedbox panel (if not furnished predrilled).
- Drilling and countersinking holes in the resilient deck and feedbox panel (if not furnished predrilled).
- Installing new bumper bars (where required).
- Bolting the panels in place.

Figure 12 shows an inclined sizing screen equipped with a blank, resilient feedbox panel and a resilient screen deck. As mentioned earlier, a feedbox handling coarse material with a large drop height from the feed chute should have a thicker resilient pad at the point of impact. This pad can be bolted to the metal (screen) feedbox, as shown at the right of figure 13.

Installation of the side wing liners, shown in figure 13, requires the following modifications to the previously installed side wings:

Drilling or burning boltholes through the top and bottom of the side wings. (CAUTION.--Do not drill through the side plates of the screen unless the manufacturer has provided approval for the holes, since this can affect the structural integrity of the screen.)

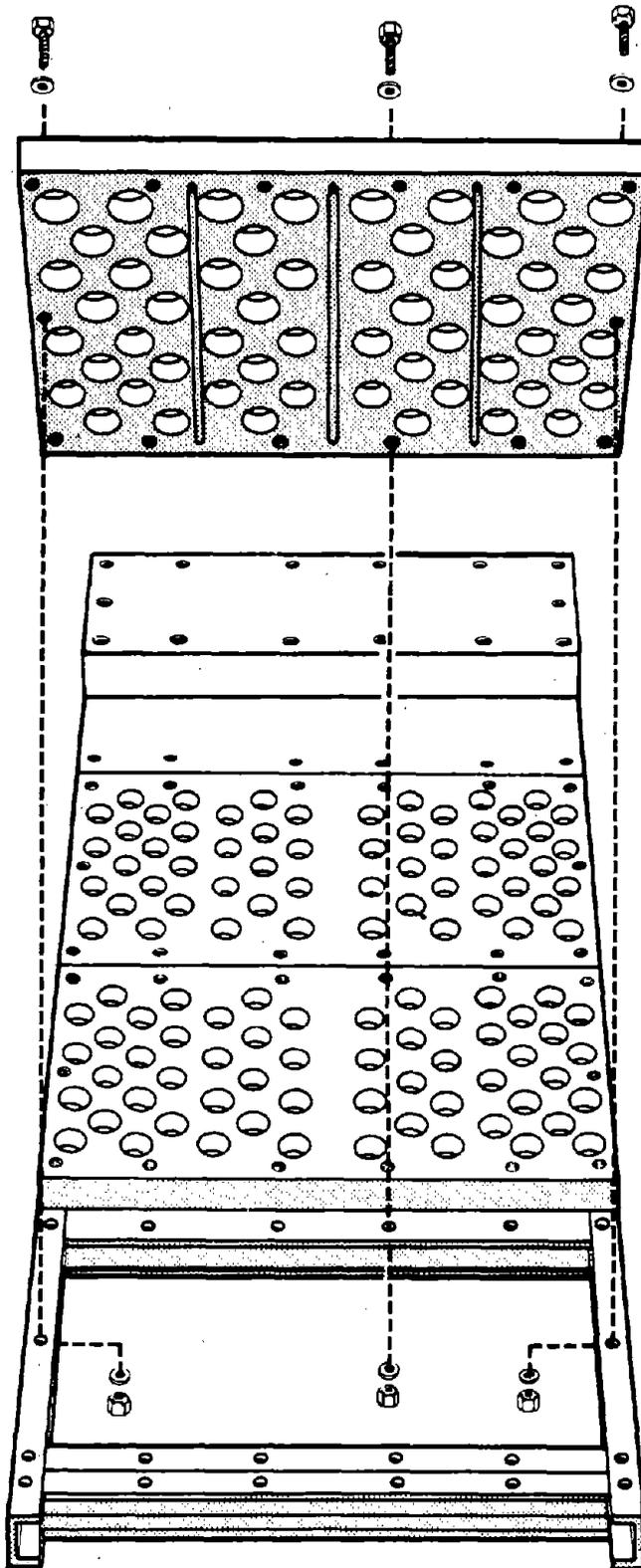


FIGURE 11. - Installation of a bolted resilient screen deck and blank impact panel.

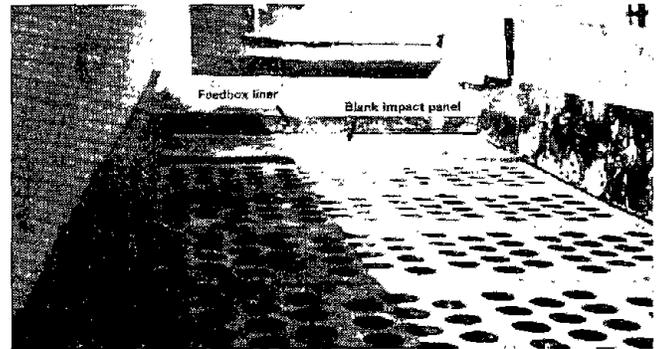


FIGURE 12. - Bolted resilient deck with blank panel in the feedbox.

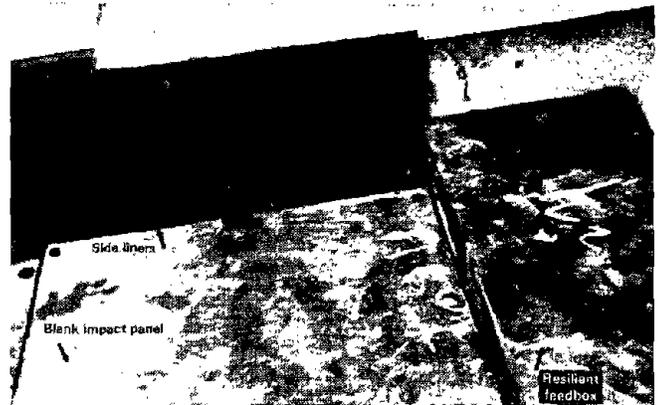


FIGURE 13. - Resilient feedbox with impact pad where product from the chute strikes the feedbox.

Locating, drilling, and countersinking bolt holes through the resilient liner.

Bolting the liner in place.

Thicker liner sections (fig. 14) can also be bolted along the length of the side wings and/or at the discharge lip to funnel the product flow towards the center of the screen deck. An installed side wing liner is shown in figure 15.

Installation of a resilient deck using side-tension rails is shown in figure 16. Installation requires--

- Removing the steel deck and side-tension rails.
- Locating, drilling, and countersinking boltholes through the resiliently lined, side-tension rails.

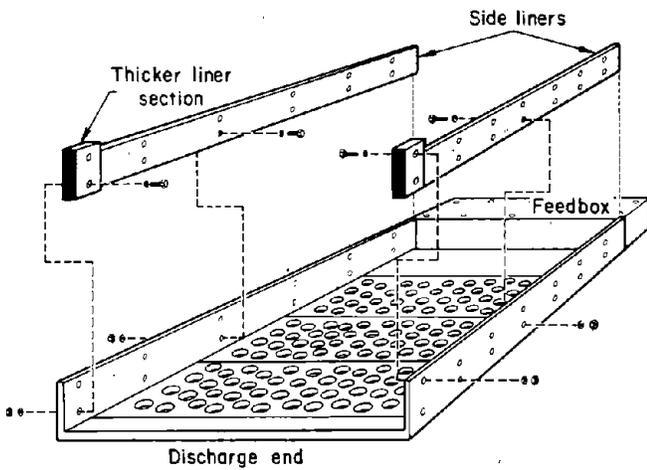


FIGURE 14. - Installation of resilient side wing liners.

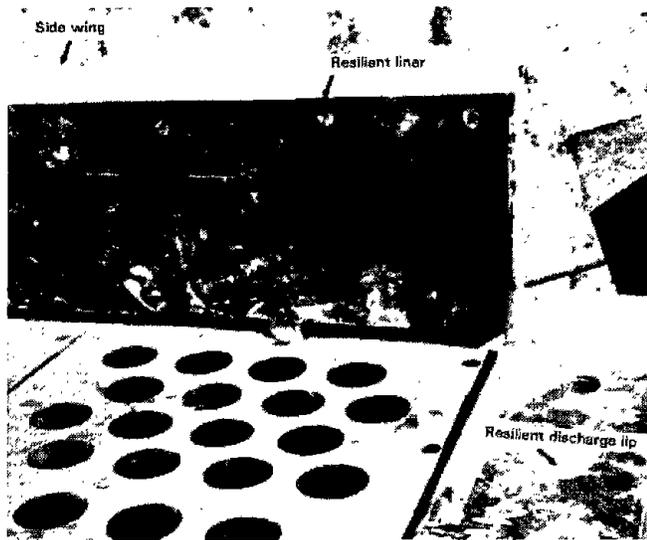


FIGURE 15. - Resilient liners bolted to screen side wings.

- Installing resilient protective moldings (bumper strips) on screen support members.
- Installing the deck and side-tension rails on the screen frame.
- Clamping the screen deck using either J-hooks with resilient protective blocks or rings, or using a center bar clamp with resilient protective molding.

Figure 17 shows a resilient screen deck equipped with resiliently lined, side-tension rails that had been installed on a horizontal screen. The completed

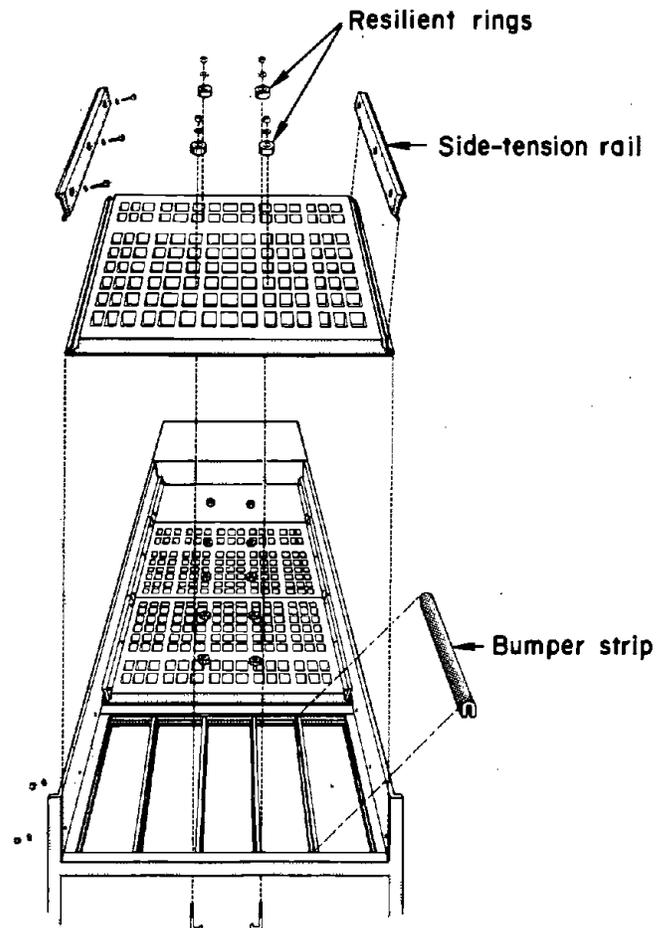


FIGURE 16. - Installation of a resilient screen deck using side-tension rails (longitudinal screen deck support).

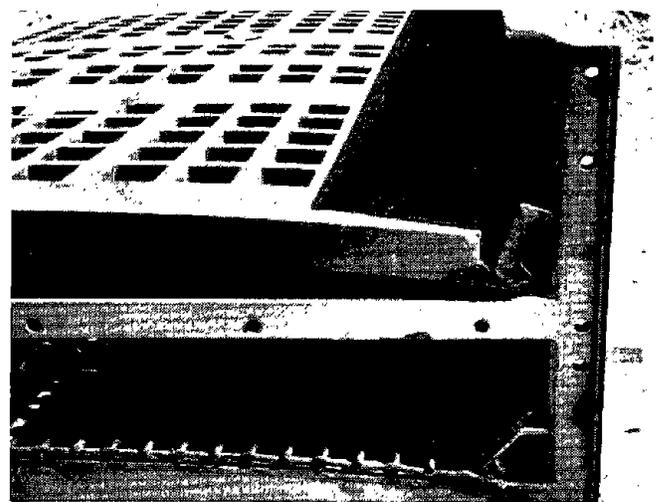


FIGURE 17. - Resilient screen deck with resiliently lined, side-tension rails.

installation with protected J-hook clamping is shown in figure 18.



FIGURE 18. • Resilient deck installed on a horizontal screen using resiliently lined, side-tension rails and J-hook clamps.

The screen discharge lip and discharge chute liners are also bolted in place. For the screen discharge lip (fig. 19), any existing steel wear plates are removed and the resilient liner is bolted in place. Side lip liners can also be bolted to the screen side wings. As mentioned, the side liners installed at the discharge should be thicker than the side wing liners along the deck to funnel the material flow and prevent product from jamming between the screen and the adjacent screen discharge hopper. Figure 20 shows a resilient discharge lip and thicker side liners installed on an inclined sizing screen.

Installation of resilient liners for a screen discharge chute, which feeds a crusher by choking the product flow down to the size of the opening of the crusher, is illustrated in figure 21. These liners are also bolted to the bottom and sides of the steel chute. Figure 22 shows the treatment of a screen discharge chute at a secondary sizing plant. Note that the boltheads are countersunk in the resilient material to protect against excessive wear caused by product sliding over them, and also to eliminate a

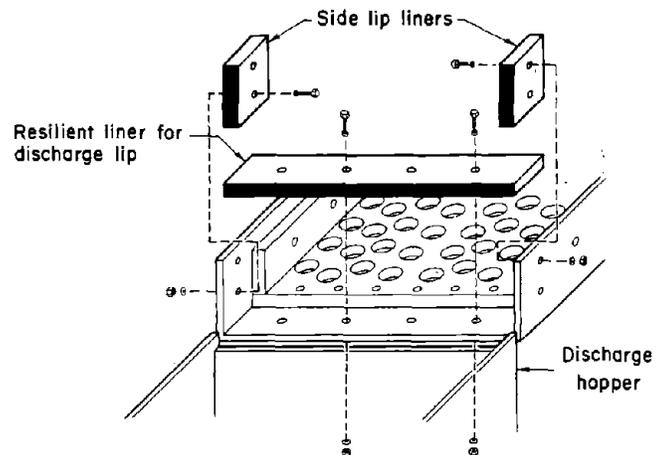


FIGURE 19. • Treatment of the screen discharge lip.

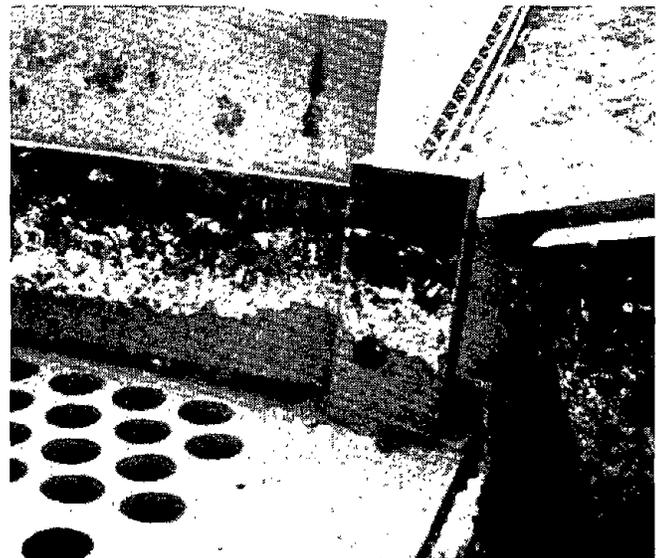


FIGURE 20. • Resilient discharge lip with thicker side liners to funnel the screen discharge.

potential secondary noise source that is caused by the product striking the metal bolthead.

The use of a resilient screen deck can cause potential operating problems, primarily decreased screening efficiency because of plugging of screen openings. These problems have already been

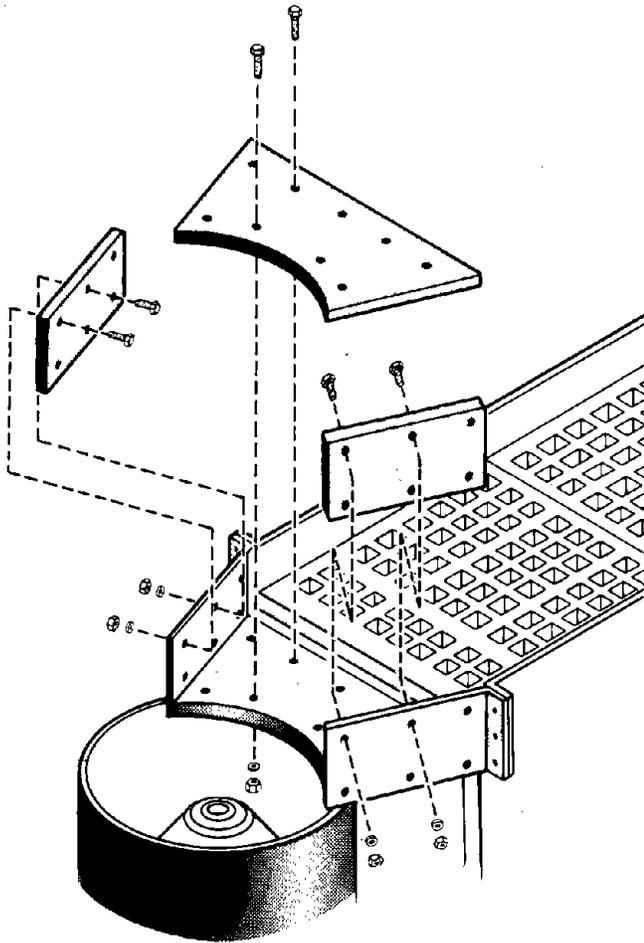


FIGURE 21. - Installation of resilient liners on a screen discharge chute.

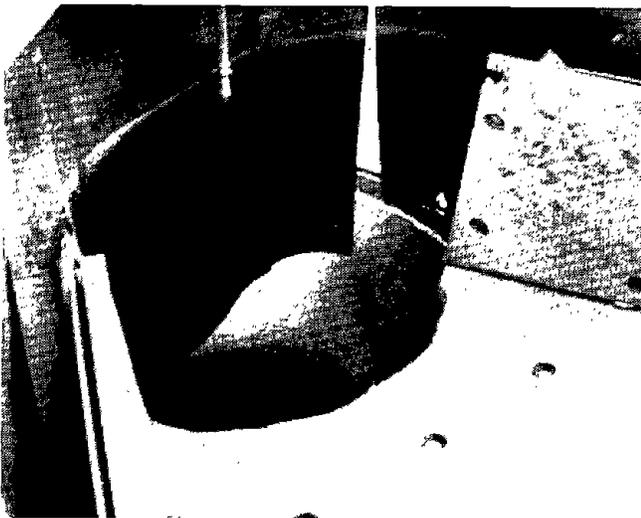


FIGURE 22. - Resilient liner in a screen discharge chute directly feeding a crusher.

discussed earlier in this report. Other potential problems include--

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

- Resilient decks may require changes in the screen's throw amplitude, speed, and direction to maintain the usual productivity and screening efficiency. Most screens have this flexibility; if changes are required, the manufacturer or the screen operating manual should be consulted.

When product strikes a resilient surface, it tends to bounce more than when it strikes steel. This higher bounce combined with the increased thickness of a resilient screen deck can result in clearance problems between the deck and either overhead or between-deck vibrators. If product does strike the vibrator, a resilient pad should be added to the vibrator housing to prevent potential damage. Another alternative for an overhead vibrator would be to install a spreader curtain at the screen feed end. This spreader curtain, made of used conveyor belting, can be attached to the feed chute to help distribute the screen bed depth uniformly and minimize product bounce. The belting should be attached to the chute and extended to the underside of the vibrator. Do not attach the belting to the vibrator; rather let it hang free to raise as product passes under it.

The higher bounce can also create safety and feed distribution problems, particularly on an inclined screen processing coarse feed. The product striking the resilient impact pad in the screen feedbox may tend to bounce further down the screen, thus negatively affecting the distribution of the product along the screening surface; given the right set of circumstances, the product may bounce over the screen side wings. To eliminate both the feed distribution and safety problems, a drag curtain should be installed over the feed chute discharge (fig. 23).

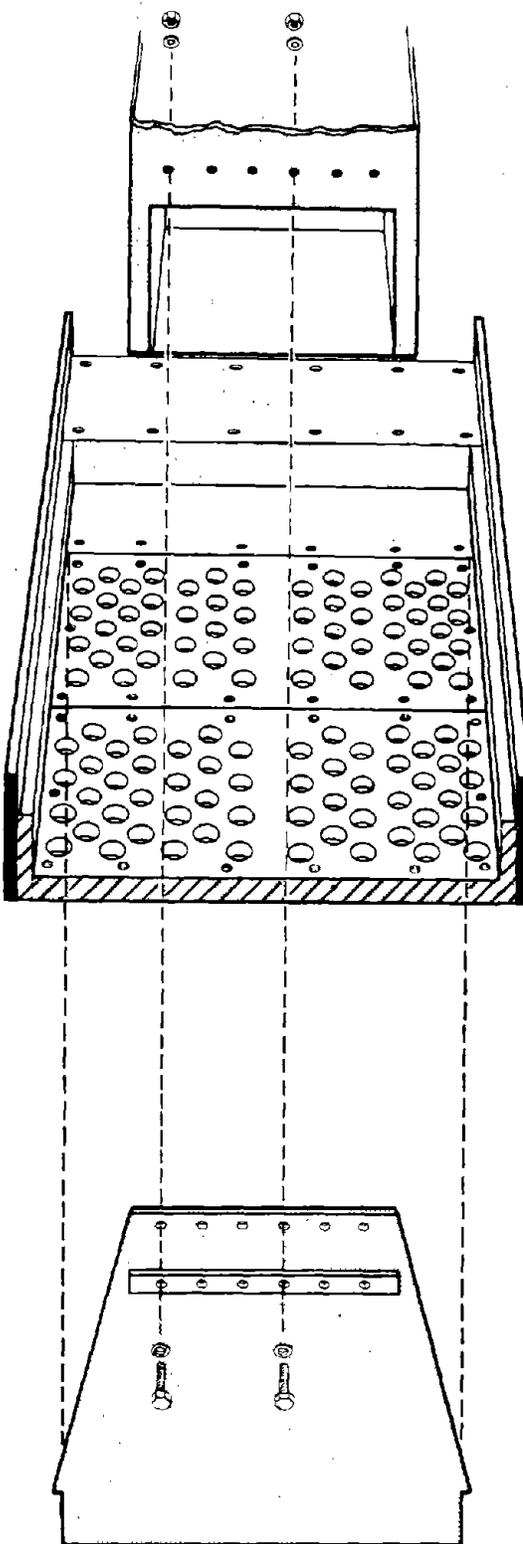


FIGURE 23. - Installation of a drag curtain over the feed chute discharge.

The drag curtain should be made of a heavy, abrasion-resistant, resilient material. (Conveyor belting is not recommended because it wears rapidly and does not have enough mass to retard the product flow.) The drag curtain should be the full width of the screen and should extend from the top of the feed chute discharge opening to the end of the blank panel. The curtain can be bolted to the feed chute; installation of a drilled steel bar, inserted between the curtain and the boltheads, is recommended for added support. A drag curtain that has been installed on an inclined sizing screen is shown in figure 24.

The use of a resilient deck may also require changes in the screen's throw amplitude, speed, and direction to maintain productivity and screening efficiency. For example, if the screening efficiency decreases (too much near-size product is being discharged off the screen deck), the throw direction can be changed from with-flow to counterflow rotation. If the bed depth becomes too shallow, the speed can be reduced along with the throw direction. This will result in a thicker bed depth. The amplitude of the throw can also be varied to obtain a more desirable operating condition. In fact, all three of these parameters may have to be changed to optimize the screening capacity and efficiency.

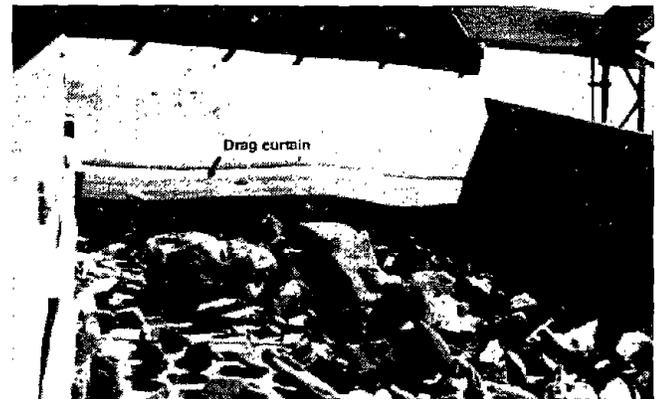


FIGURE 24. - Drag curtain installed on an inclined screen.

Although these changes were not made at any of the three cooperating quarries, the researchers had discussed these possibilities with them. An important point

to remember is that manufacturer's recommendations should always be requested before any operating parameters are changed.

NOISE CONTROL TREATMENTS FOR A CONE CRUSHER

A typical secondary crushing and screening plant uses a cone crusher to reduce the oversized product from the screen. This oversized product is transferred into a steel hopper that feeds the crusher and then into the crusher feed cone, which is typically equipped with steel wear liners. The screen discharge also strikes the crusher feed plate and/or the mantle hold-down cap.

High noise levels are generated when the product impacts these steel components, and by the actual crushing process, which produces noise from the crusher main frame. Noise levels measured beside cone crushers typically exceed 110 dBA.

The recommended noise control treatments for a cone crusher include--

- Resilient liners for a surge-type feed hopper, feed cone hopper shell, and the feed cone.
- A resilient feed plate or pad for the mantle hold-down cap.
- A barrier curtain around the exterior of the crusher main frame.

DESIGN AND SELECTION OF NOISE CONTROL TREATMENTS FOR CONE CRUSHERS

Noise treatments for the crusher surge hopper, feed shell, and cone should be designed after the resilient deck has been installed and any adjustments to the screen have been completed. This sequence of treatment is recommended because the product flow from the screen may change, thus changing the impact points in the feed hopper. The crusher feed cone and the feed cone hopper can be treated completely because they rotate during liner wear and/or setting. Resilient linings are required for all hopper surfaces impacted by the product,

not only during full-load operation, but also during screen startup and shutdown. Proper design of the liner for the crusher surge hopper requires supplying the manufacturer the following information:

Size and type of product.

Drop height or velocity of the product at impact.

Dimensions of the hopper.

Sketch of the hopper showing impact areas.

Location of dust suppression spray bars, if used.

If the hopper is large, the lining may have to be manufactured in sections to minimize installation and handling problems. Additionally, it is recommended that the lining sections be interchangeable, if possible. This flexibility will allow the panels to be rotated to accommodate uneven wear rates. It is also recommended that the lining be designed so that it can be suspended away from the hopper wall. This type of installation will reduce the localized crushing forces on the liner, and thus reduce the required liner thickness.

Resilient linings 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 interfere with the material flow through the crusher. Ideally the shell and cone liners should be a one-piece assembly. 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. 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. The new feed plate should be cast by the material manufacturer using a mold that matches the steel one. It is, however, recommended that the resilient plate be manufactured thicker and larger in diameter than the steel one to prevent premature failure of the material located between the hold-down 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.

For crushers without a feed plate, a resilient pad for the mantle hold-down cap is recommended. The pad would also have to be custom cast by the material manufacturer to match the existing hold-down cap. This treatment is not necessary if the crusher is consistently choke fed. A crusher that is choke fed has sufficient product in the crushing cavity to protect the mantle hold-down cap from impact. This is the same noise control technique as the dead bed for a product-transfer chute.

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. The curtain should be fabricated from loaded 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. The curtain should be long enough to go completely around the crusher, plus one extra foot for an overlap that will ensure the acoustical integrity of the treatment.

INSTALLATION OF NOISE CONTROL TREATMENTS FOR CRUSHERS

The resilient liner for the crusher feed hopper can be either bolted directly to the hopper wall or can be suspended away from the wall to improve wear. A suspended liner is shown in figure 25. In this suspended installation, the liner was bolted to the hopper wall along the top edge and allowed to hang freely. The bolts, which are above the impact area, did not have to be countersunk in the material.

The crusher feed cone shell and feed cone liners, if fabricated as a one-piece assembly, can be simply forced into place (fig. 26). This is done after removal of the steel wear plates or bars that might have been installed. The shell liner can also be bolted in place with a steel ring for added support. An installed one-piece resilient crusher feed cone is shown in figure 27.

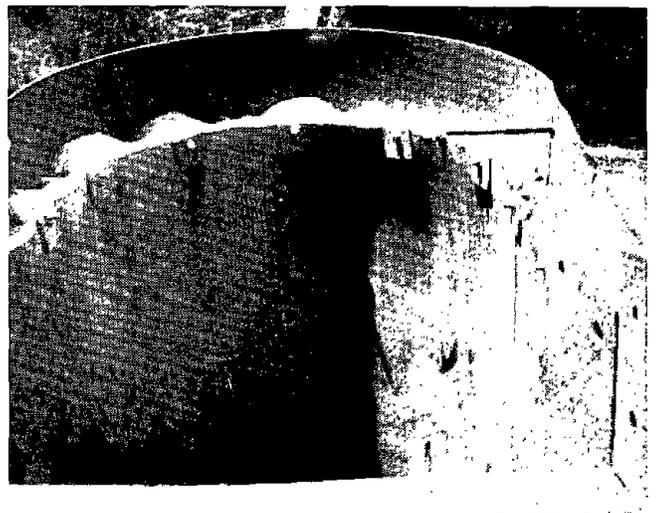


FIGURE 25. - Resilient liner installed in the crusher feed hopper.

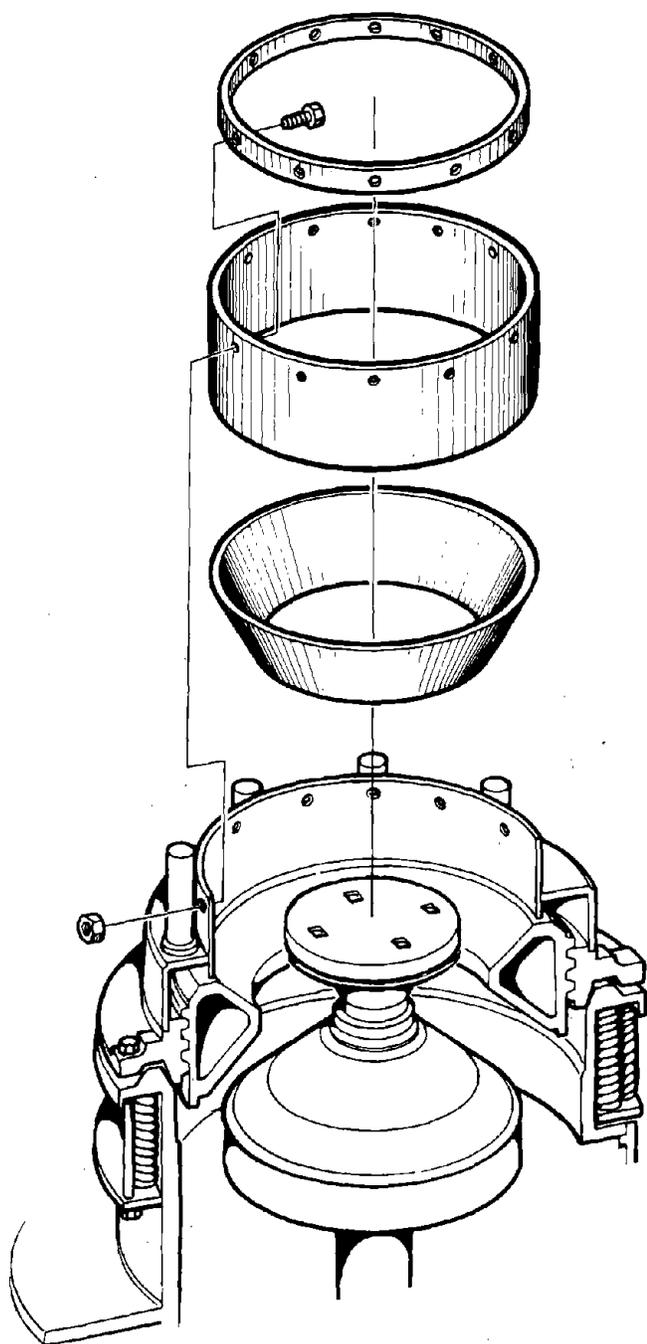


FIGURE 26. - Installation of a resilient crusher feed cone shell liner.

The installation of a segmented resilient feed cone liner requires--

- Removing any steel wear liners.
- Burning or drilling boltholes through the feed cone.

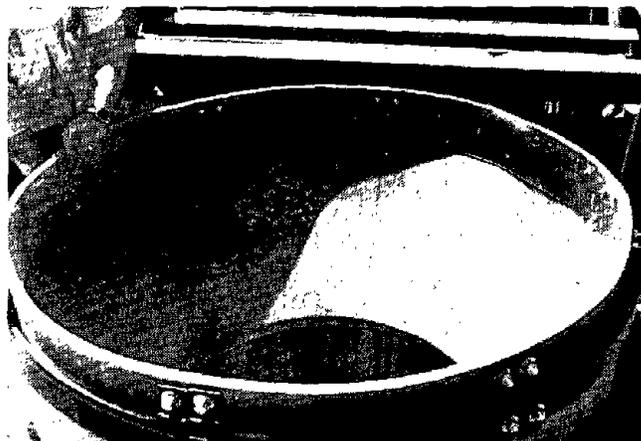


FIGURE 27. - Installation of a one-piece resilient crusher feed cone liner.

- Locating, drilling, and countersinking boltholes in the resilient liner segments (if not ordered that way from the material vendor).

- Bolting the segments in place.

The installation of resilient liner segments in a feed cone is shown in figure 28.

The installation of the resilient feed plate (fig. 29) is straightforward. The old feed plate is removed and the new feed plate is bolted in place.

Installation of a resilient pad on the mantle hold-down cap (fig. 30) would require--

- Cleaning product from the recess for the main shaft bolt.

- Welding a mounting bolt for the pad on the head of the main shaft bolt.

- Installing the pad, making sure that the bolt and nut are below the pad surface.

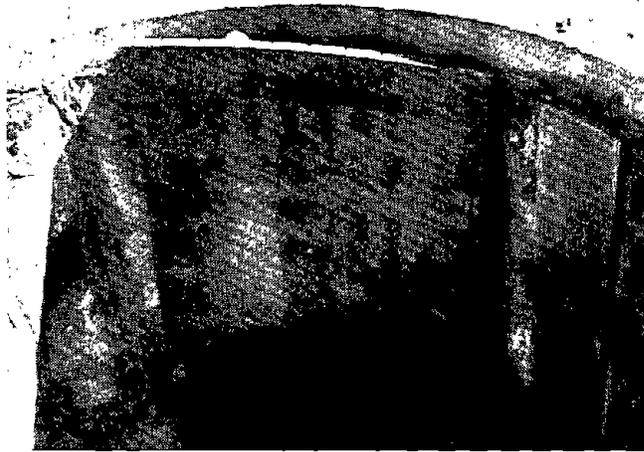


FIGURE 28. - Installation of resilient feed cone liner segments.

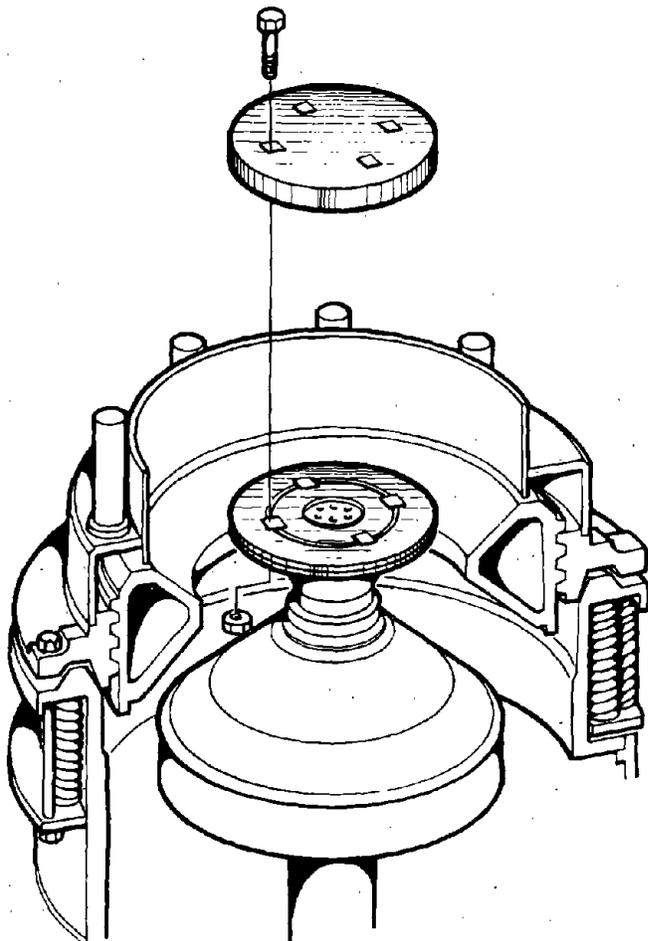


FIGURE 29. - Installation of a resilient crusher feed plate.

The noise barrier curtain (fig. 31) is attached to the adjustment ring and hangs freely to the base of the main frame flange. This free hanging will allow vertical movement when the crusher passes

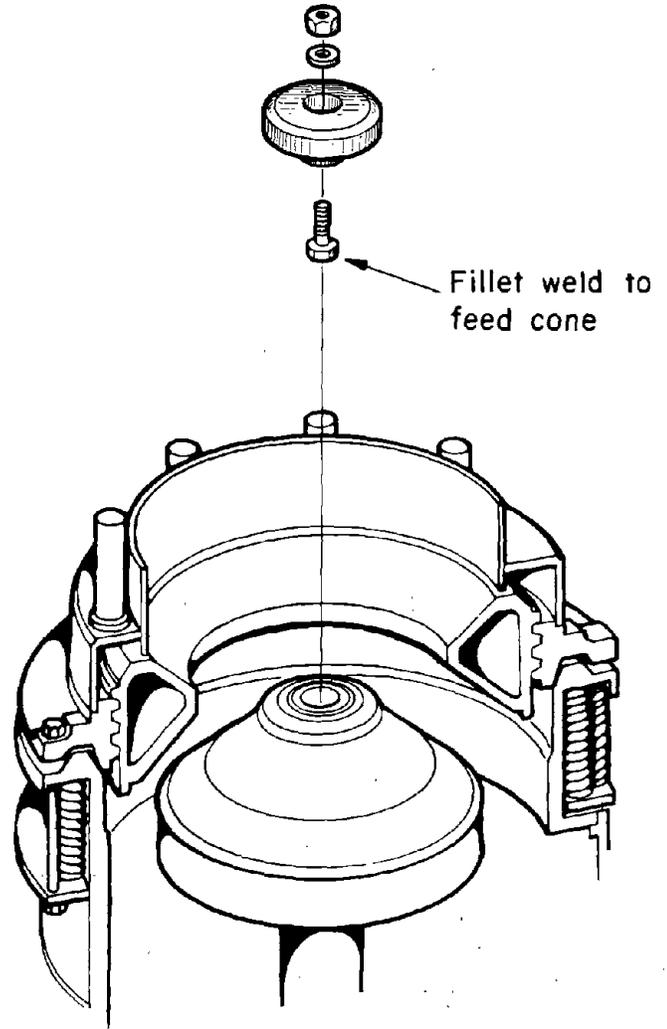


FIGURE 30. - Installation of a molded resilient pad for the mantle hold-down cap.

tramp iron and will not interfere with normal crusher servicing. Installation of the curtain requires the following:

- Use the curtain grommets as a template to mark locations on the crusher adjustment ring.
- Weld studs or cap screws to the adjustment ring at the marked locations.
- Mount the curtain on the studs or screws.
- Make cutouts in the curtain for hydraulic lines and around the crusher countershaft box.

An installed curtain is shown in figure 32.

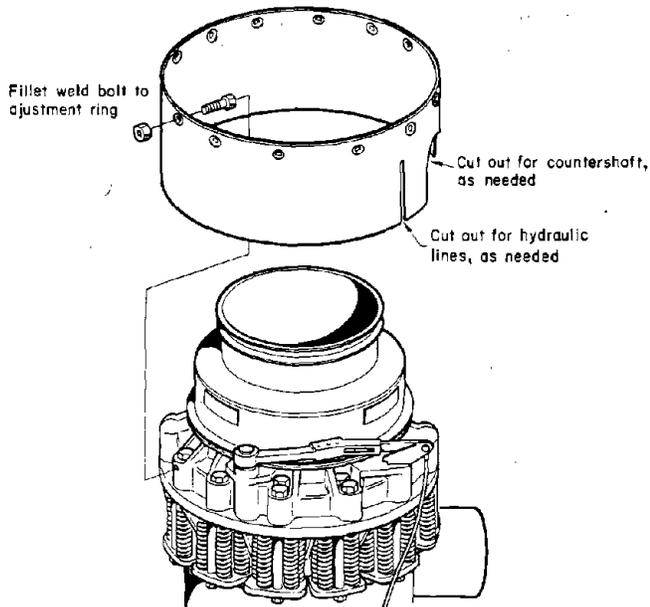


FIGURE 31. - Installation of a barrier curtain around the crusher main frame.

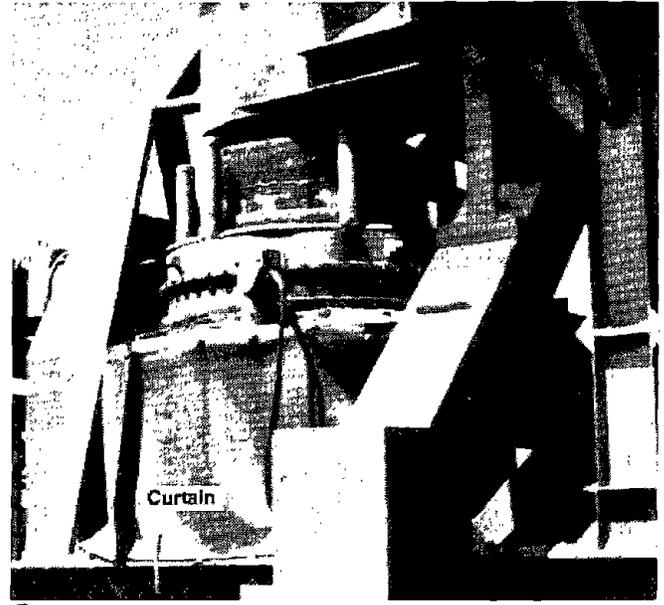


FIGURE 32. - Noise barrier curtain installed around the crusher main frame.

NOISE CONTROL USING AN OPERATOR CONTROL BOOTH

The noise control treatments described in the previous sections were aimed at reducing noise at the source or enclosing the noise source. Another treatment, which is extremely cost effective for stationary plant employees, is the construction of a control booth. A control booth is not expensive to construct or purchase, can provide noise reductions of 15 to 25 dBA, requires very little maintenance after installation, and also helps protect the operator from the weather and other environmental hazards, such as dust.

GENERAL SELECTION GUIDELINES

The construction or purchase of a booth is straightforward and quite a number have been installed in the industry. Many, however, are not as effective as they could be for the following reasons:

The booth is not large enough.

The booth does not have adequate air-conditioning.

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

The booth is not acoustically tight.

The booth is mounted directly on 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 going to provide maximum noise reduction it must be tightly constructed. Any holes or openings in the booth will let outside noise pass inside. Many plants have installed booths that look nice, but do not provide adequate noise reduction because they fail to seal leaks (after construction) around doors, windows, or where control cables have to pass through the booth. These types of leaks can easily reduce the effectiveness of a booth by 10 to 15 dBA.

The effectiveness of a booth can also be compromised by where and/or how it is mounted. A booth mounted directly on the

plant structure will have vibrations from this structure pass directly into the booth's structure. This vibration, which is usually severe, causes the booth's surfaces to radiate noise. If the booth has to be mounted on the plant structure, correctly designed vibration isolators will have to be used. An alternative would be to mount the booth on a separate structure that is not in contact with the plant; the plant controls would have to be relocated to the booth.

GENERAL CONSTRUCTION GUIDELINES

A control booth can either be purchased or can be constructed by plant labor. The construction of an effective booth, however, requires some modification of standard building practices.

The walls of an effective booth can use a standard 2- by 4-in stud construction, with a 5/8-in plywood exterior. The interior, however, should have a double layer of gypsum wallboard with staggered joints. The wall should be insulated with a fiberglass that is attached to the exterior wall; this is primarily for temperature control. The thickness of the fiberglass should be less than the thickness of the stud. The basic construction is shown in figure 33.

The roof of the booth can be a standard construction, but must be sealed at the wall joints. A drop ceiling using acoustical tile is recommended inside. The booth floor can also be standard construction. A double floor layer (with

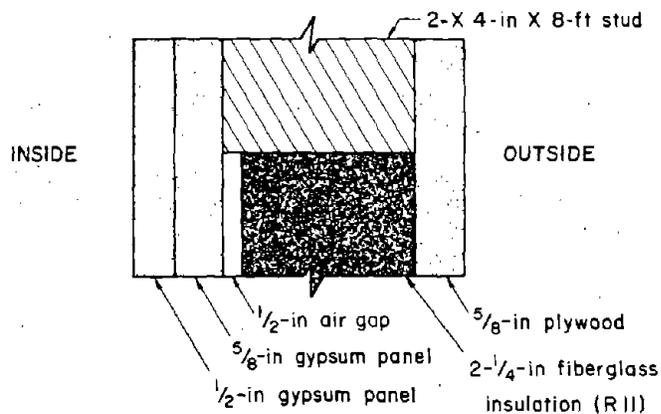


FIGURE 33. - Basic control booth wall construction.

staggered joints) is recommended, as is tightly sealing the wall joints.

The windows should be double pane with a 3/4-in air gap between them. The windows should be mounted in the frame using rubber gaskets to provide a tight seal. The windows should be large enough to provide the operator with an adequate field of view, but no larger. Windows, even double pane, are less effective noise barriers than the surrounding walls. Making the windows larger than necessary will reduce the effectiveness of the booth.

The doors for the booth should be solid core. They can be either solid wood or a metal skin with an insulating foam core. The doorframe should also be gasketed to provide a tight seal.

After the booth is constructed, check for and plug all leaks. As mentioned before, this step is critically important and can increase the effectiveness of the booth by 10 to 15 dBA. Areas to check include--

- Doorframes and window frames.
- Wall-to-wall, wall-to-roof, and wall-to-floor joints.
- Holes cut for control and power lines.
- Holes cut for air-conditioner and heater.

It is also important to include the booth on a regular maintenance schedule. Gaskets and seals around doors and windows, for example, should be routinely checked and repaired.

TYPICAL BOOTH INSTALLATION

The control booth installed, during this research program, for a primary crusher operator is shown in figures 34 through 37. The 8- by 10-ft booth was purchased for \$4,919. The booth was mounted on a separate support structure that was constructed by quarry personnel using 6-in I-beams. It reduced the noise levels at the operator's location from 97 to 78 dBA.



FIGURE 34. - View of a primary crushing plant with an operator control booth.

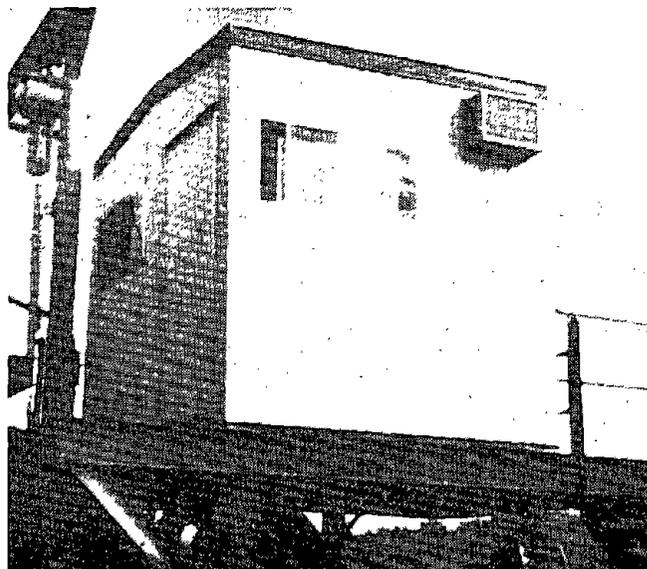


FIGURE 35. - Operator control booth mounted on separate steel support structure.

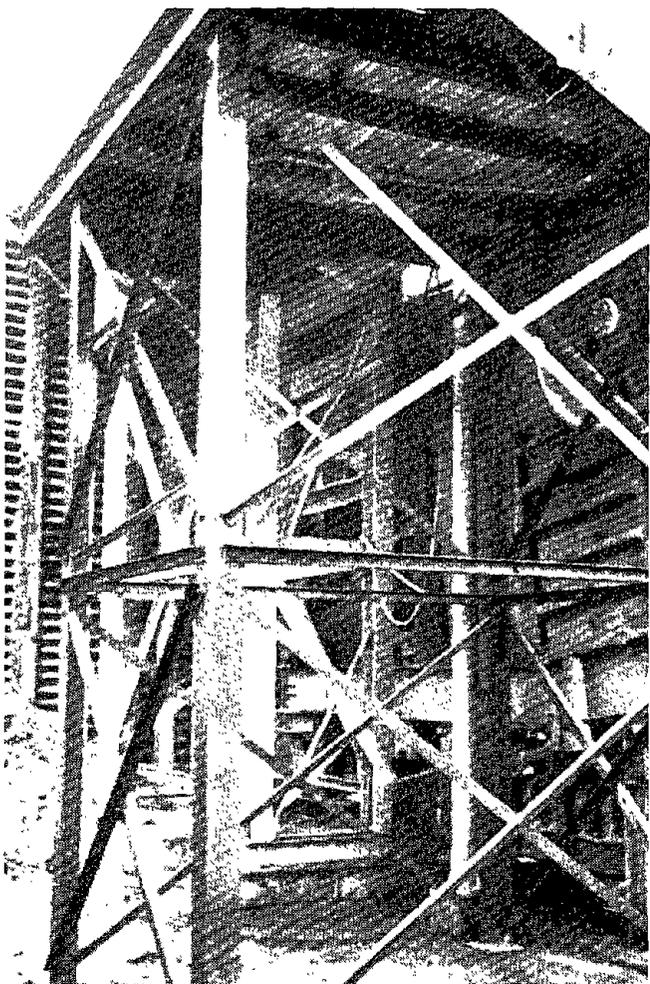


FIGURE 36. - Separate control booth support structure constructed by quarry personnel.



FIGURE 37. - Primary crusher operator at the control station inside the booth.

SUMMARY AND CONCLUSIONS

Treatment techniques employed the use of commercially available, wear-resistant, resilient materials. These products can be utilized for noise abatement by all sizes of crushing and screening operations. Treatment costs for the portable plants were about 5 to 7 pct of the purchase price of a new 200- to 300-ton/h plant. Reasonably maintained plants invest this amount annually to repair material handling equipment or product transfer points. The wear performance, the noise reduction, and the reasonable cost of the resilient products have led to the conclusion that retrofit noise treatments can be economically applied to all sizes of crushing and screening plants. Additionally, manufacturers of crushing and screening plants can easily incorporate noise control technology as the plants are built, thus

addressing additional noise sources. A retrofit program can only modify field-accessible areas; new plants, however, can be designed and fabricated to incorporate resilient materials for improved wear and noise control from the beginning of the project. For example, the sizing screen feedbox seems to be a high maintenance area; the feedbox could be routinely fabricated with a resilient impact pad incorporated for the requirements of a specific plant. Cost tradeoffs for new plants are possible when wear-resistant, resilient materials are substituted for abrasion-resistant metals. Thus, the program results have indicated that the modifications that were tested could be expected to result in lower noise levels and reduced maintenance when applied to the design of a new plant.