

Bolt Beranek and Newman Inc.



**Demonstrating the Noise Control
of a Coal Preparation Plant
Volume I. Initial Installation and Treatment Evaluation**

Prepared for:

**United States Department of the Interior
Bureau of Mines**

By

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Final Report

on

**Contract No. USBM H0155155
Demonstrating the Noise Control of a Coal Preparation Plant
Volume I.**



(June 1975 — August 1977)

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16. Abstract This report summarizes the work performed under USBM Contract No. HO155155, "Demonstrating the Noise Control of a Coal Preparation Plant." A Consolidation Coal Company coal preparation plant (the Georgetown Plant) was selected for demonstration of various noise control techniques and materials in a commercially operating plant. At the start of the project, the 1650 tons per hour (tph) plant was surveyed to document the existing sound levels and worker noise exposures. On the basis of the survey, individual noise sources were characterized and assigned priorities for treatment. Four categories of noise control treatments were installed in this plant: <ul style="list-style-type: none">• Resilient impact pads• Curtains• Chute liners• Resilient screen decks. Currently (1977) available resilient impact pads and curtains were found to be suitable for general use in coal preparation plants; in the Georgetown Plant, they provided significant noise reduction [6 to 10 dB(A)]. The overall performance of the chute liners, which also provided useful noise reduction, was strongly dependent on the specific installation. Although the resilient screen decks have the potential for 7 to 9 dB(A) of <i>coal/screen impact noise</i> reduction, blinding and delamination (in composite decks) encountered at the Georgetown Plant represented major design problems for these products. This program achieved noise reductions of up to 10 dB in various areas of the Georgetown Plant (within the restrictions imposed by the plant's operation) resulting in significant reduction in worker noise exposures.			
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ABSTRACT

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- Resilient impact pads
- Curtains
- Chute liners
- Resilient screen decks.

Currently (1977) available resilient impact pads and curtains were found to be suitable for general use in coal preparation plants; in the Georgetown Plant, they provided significant noise reduction [6 to 10 dB(A)]. The overall performance of the chute liners, which also provided useful noise reduction, was strongly dependent on the specific installation. Although the resilient screen decks have the potential for providing 7 to 9 dB(A) of *coal/screen impact noise* reduction, blinding and delamination (in composite decks) encountered at the Georgetown Plant represented major design problems for these products.

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imposed by the plant's operation) resulting in significant reduction in worker noise exposures.

FOREWORD

This report was prepared by Bolt Beranek and Newman Inc., Cambridge, MA, under USBM Contract No. H0155155. The contract was administered under the technical direction of PM/SRC, with Dr. H.K. Sacks as technical project officer. Mr. P.B. Schultz was the contract administrator for the Bureau of Mines.

Work completed between June 13, 1975 and August 31, 1977 is summarized in this report, which was submitted in September 1977.

In addition to the above-named organization and personnel, the author would like to thank Mr. Duke Zinko and Mr. John Stock of Consolidation Coal Company for their interest and assistance. The author would also like to thank two former employees of BBN, Mr. William Patterson and Mr. Geoffrey Huggins, who provided much of the initial effort in the project while with BBN.

EXECUTIVE SUMMARY

E.1 Introduction and Background

The number of noise control products being marketed to the mining and ore-processing industry has increased significantly in recent years, and has been spurred by the industry's desire to comply with the noise exposure regulations under the Coal Mine Health and Safety Act of 1969 (CMHSA). While some of these materials are relatively new and designed specifically for the mining industry, many are adaptations of noise control treatments used successfully in other industries. As a result, performance data for these products either were not readily available or were extrapolated from other industries. Since coal preparation has a number of unique material-handling problems, data based on the experience of other industries may not be directly transferable.

The project described in this report was designed to answer questions of noise control in coal preparation plants by providing quantitative information on such parameters as acoustic performance, cost, installations and maintenance requirements, service life, etc. on the basis of direct experience within the coal industry.

At the outset, it was decided that the most efficient method of obtaining such information would be through the installation and evaluation of a variety of noise control treatments within a single demonstration plant. Not only would this method provide valuable direct experience with the treatments, it would also provide information on the effect of such a noise control program on general plant sound levels.

E.2 Demonstration Plant

Consolidation Coal Company's Georgetown Preparation Plant was selected as the demonstration plant for this project, because of its representative selection of equipment and personnel assignments as well as the cooperation of CONSOL personnel. Built in 1951, the Georgetown Plant processes approximately 1650 tons per hours of raw coal. As Fig. E.1 shows, the raw coal is separated into three size ranges (by a set of secondary sizing screens), each of which is cleaned by different equipment. The smallest material (0 in. \times 3/8 in.) is cleaned and dried with Deister tables and Reineveld centrifugal dryers. Material between 3/8 in. and 1½ in. is cleaned by Chance Sand Flotation Cones. McNally jigs (or washboxes) are used to clean the largest size (1½ in. \times 7 in.).

Table E.1 lists the day shift workers in the Georgetown Plant. The workers identified as "stationary" are primarily specific equipment operators, who remain at a single location for the majority of their shift on a daily basis.

TABLE E.1. GEORGETOWN PLANT PERSONNEL (DAY SHIFT).

Stationary Workers	Mobile Workers
Picking Table Operator	Mechanics (6)
Washbox Operator	Clean Up (4)
Panel Board Operator	Pan Line (1)
Deister Table Operator	Oiler (1)
Loadout Operator	Sampler (1)
Car Shakeout Operator	Coal Inspectors (2)
Warehouse Tender	Electricians (2)
	Master Mechanic (1)
	Foreman (1)

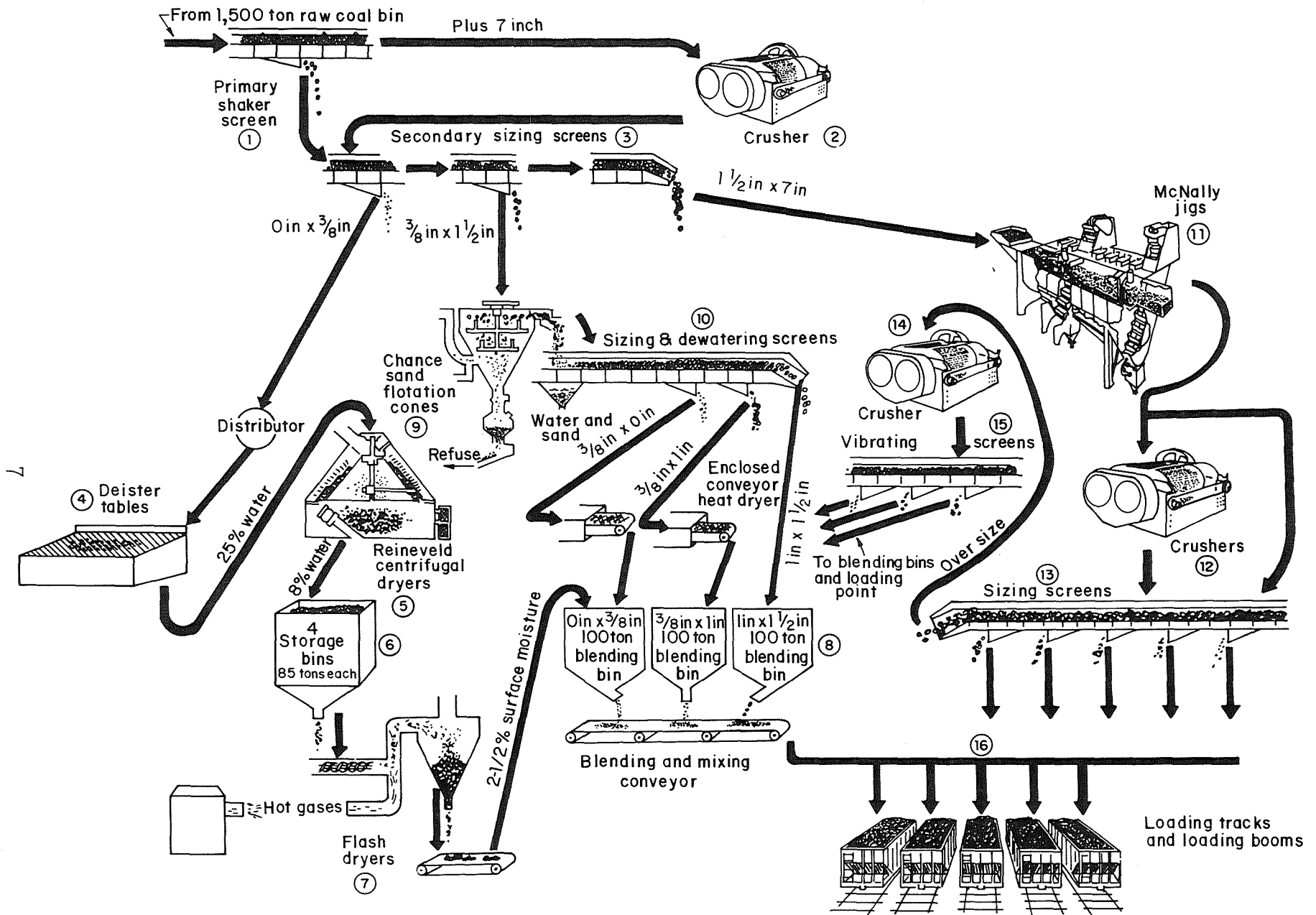


FIG. E.1. FLOW SHEET FOR GEORGETOWN PREPARATION PLANT.

The mobile workers, such as mechanics, do not remain at the same location on a day-to-day basis.

E.3 Noise Control Program

A sound level and operational survey of the plant was conducted at the start of the program to identify the major noise sources and worker noise exposures, and to define the operational restrictions that would affect the design of the noise control treatments. In addition, individual plant areas were categorized according to the amount of time plant employees spent within each area, as follows:

Type I — Continuous-exposure area, in which at least one person is located for his entire shift.

Type II — Frequent-exposure area, in which workers (primarily mobile) are located for one-half to two-thirds of their shift.

Type III — Limited-exposure area, in which personnel are located for one hour or less per day.

With the information obtained from the survey, each of the major noise sources within the plant was ranked according to the exposure classification of the area within which they were located, as well as the measured sound levels and the desire to experiment with a variety of noise control materials. Table E.2 lists the major noise sources, the representative A-weighted sound levels around the machines, and the exposure classifications of the areas in which the machines were located. For this first phase of the project, the pieces of equipment selected for treatment were primarily those items listed in Table E.2, that were located in either continuous- or frequent-exposure (Type I or II) areas.

TABLE E.2. NOISE SOURCES AND EXPOSURE CLASSIFICATIONS

Equipment Description	Representative Sound Level in dB(A)	Exposure Classification
Oak Park Belt Drive	92 - 94	III
Rom Belt Drive	91	III
Primary Screen	94	II
Picking Table	94+	I
McLanahan Rock Crusher	Impulses to 100	I
Secondary Sizing Screens	95 - 97	II
McNally-Baum Jigs	94 - 97	I
Middling Shakers	94 - 97	I
Jeffrey 5 ft x 9 ft Feeders	95	III
Clean Coal Desanding Screens	96 - 97	II
Ripl-Flo Feed Conveyor	94 - 95	II
Dryer Feed Conveyor	90	III
Grundlach Coal Crushers (4)*	96	II
Ripl-Flo Screens (7)	101	II
Vacuum Pump	95	III
Cone Refuse Desanding Screen	97	III
Reineveld Centrifugal Dryers (7)	97 - 103	II
Wemco Dryers (6)	95 - 96	II
Classifying Screens	102 - 104	II
Rail Car Shaker	111 - 113	II
Flash Dryers	-	III
Middlings Crusher	-	III
Jig Refuse Shaker	96	III
Syntron Feeders	108	III
Jig Blowers	99	III

*Numbers in parentheses refer to the number of individual machines of each type in use.

The noise control treatments installed in the Georgetown Preparation Plant under Phase I of this project can be divided into four general categories:

- Resilient screen decks
- Resilient impact pads
- Chute liners
- Curtains.

Several types of laminated (resilient layer bonded to steel punch plate) and all-resilient screen decks were installed on

both low-speed crank-arm and high-speed eccentric-weight shakers. These installations are summarized in Table E.3. Acoustic measurements taken during this program indicate that resilient screen decks have the potential for providing noise reductions of 7 to 9 dB at positions close-in to the screen. This is primarily a result of reducing the noise generated as coal impacts the screen deck. In practice, the achievement of this reduction at typical worker locations, alongside the shakers, may also require treatment of the noise generated at the infeed and discharge chutes, bottom pan, and drive mechanism (for high-speed shakers).

A number of the screens installed at the Georgetown Plant tended to blind during operation. This blinding (i.e., plugging of the screen holes by pieces of coal that become lodged within the holes) varied from 10% to 70% with the thick, all-resilient deck materials more prone to blinding than the thin laminated decks. Several of the laminated decks, on the other hand, exhibited some separation or delamination of the resilient layer, preventing an accurate assessment of the abrasive wear characteristics of these decks.

While the *initial installation time* for the resilient decks ran up to $2\frac{1}{2}$ times the *replacement time* for the original steel decks, because of required modifications in mounting brackets, etc., the *replacement time* for the resilient decks should be comparable to that for the steel screens. The material cost of the resilient screen decks ranged from 3 to 6 (typically 3 to 4) times the mild steel punch plate counterpart.

Both ribbed (profiled) and flat resilient impact pads were installed at the discharge ends of various belts, chutes, and screens to reduce the noise from the material (coal or rock) impacting the original steel structure. Table E.4 summarizes

TABLE E.3. SUMMARY OF RESILIENT SCREEN USAGE AT THE GEORGETOWN PREPARATION PLANT.

Manufacturer/ Supplier	Description					Cost		Location	Installation Date	Final Inspection Date	Comments
	Hole Size (in.)	Steel Thickness (in.)	Rubber Thickness (in.)	Composition	Panel Size (in.)	\$/Sq Ft	Cost Factor*				
Laubenstein	6	1/2	1/4	EAR C2003 bonded to bottom of steel deck	1- 120x48	No Charge	--	Primary Shaker- 4th screen from top	7/26/76	9/30/76	•50% of EAR material separated from steel.
Hewitt-Robins/ Laubenstein	6	3/8	3/8	"Tuffgard" bonded to steel deck (80 duro- meter)	4- 60x48	32.50	3.5	Primary shaker- 2nd & 3rd screen from top	7/12-14/76	9/30/76	•Resilient layer separating from steel at leading edges. •Removed on 11/11/76 due to blockage of coal flow.
McBride Industries	1-1/4	--	1-3/16	All urethane screen deck	1- 94x48	25.00	4.3	Secondary shakers- 2nd screen above crosshead on #2	11/18/75	12/17/75	•Removed on 12/17/75 due to excessive blinding.
Trelleborg	1-1/4	--	3/4	60 durometer rubber deck (Duenero)	1- 94x48	37.00	6.3	Secondary shaker	10/18/75	10/31/75	•Removed on 10/31/75 due to excessive blinding.
	1-1/4	--	3/4	60 durometer rubber deck (Duenero)	1- 94x48	No Charge	--	Secondary shaker	1/13/76	1/20/76	•This is same as pre- vious screen, with a different clamp- ing arrangement. •Removed on 1/20/76 due to excessive blinding.
Hendrick "Rubber Clad" Screens	1-1/4	3/16	3/8	60 durometer rubber bonded to steel	2- 94x48	21.50	3.6	Secondary shakers	1/22/76	4/13/77	•7/13/76, leading edge of rubber be- ginning to separate from steel, one worn patch. •7/26/76, reversed screen. •Blinding ~10-15% •4/13/77 rubber worn away.
Hewitt-Robins/ Laubenstein	1-1/8 Hexag. Holes	3/16	1/4	"Tuffgard" bonded to steel deck	4- 59x42 4- 46x41	23.50	3.7	RIPL-FLO vibrators	9/17/76	2/22/77 6/23/77	•#1 screen showing some separation. Blinding 10-15% •#1 screen almost completely separ- ated.
Linatex/ Laubenstein	1-1/2 Rubber 1-3/4 Steel	10 ga	3/8	60 durometer rubber bonded to steel deck	7- 48x95	16.50	-2.7	Classifying shakers	11/29-30/76	6/23/77	Blinding ~60-70%.

*Cost Factor = $\frac{\text{Cost of Resilient Deck}}{\text{Cost of Original Steel Deck}}$

TABLE E.4. SUMMARY OF RESILIENT IMPACT PADS INSTALLED AT THE GEORGETOWN PREPARATION PLANT.

Manufacturer	Composition	Area (Sq Ft)	Thickness	Cost/Sq Ft	Approximate Installation Time (Man-hours)	Location	Installation Date	Final Inspection Date	Comments
Goodyear	Armaplate-60-durometer rubber bonded to 16-gauge steel	2.0	1/2-in.	\$ 5.60	2	Picking table	1/29/76	11/6/76	Armaplate wornout; replaced with 1-1/2 in. urethane.
McBride Industries	Urethane	3.0	1-1/2-in.	\$33.00	2	Picking table	11/6/76	6/23/77	Pad in generally good condition, showing some wear.
Trelleborg	VP plate profiled trellex 60 with steel mounting channels	11.3	2-3/16-in.	\$48.00 ¹	10	Infeed to McLanahan Crusher	9/4/76 11/15/76	6/23/77	Both pads in good condition.
		14.3	2-3/16-in.	\$63.00 ²	--	Horizontal & vertical impact points in McLanahan discharge chute	8/21/76	8/22/76 11/27/76 4/13/77	Horizontal pad removed due to backup. Vertical pad replaced due to incorrect installation. Vertical pad slipped from mounting.
Goodyear	Armaplate	3.0	1/2-in.	\$ 5.60	4	Discharge of middling vibrators	9/30/76	6/23/77	Both pads in good condition.
Trelleborg	VP plate profiled trellex 60	9.0	2-3/16-in.	\$46.00 ³		Discharge of crop conveyor		6/23/77	Pads in good condition.
		18.3 13.3	2-3/16-in.	\$32.00 \$49.00	14-1/2 14-1/2	Discharge of jig refuse elevator	11/15/75 (#2) 6/19/76 (#1)	6/23/77	Pad in #2 in good condition.
McBride Industries	Urethane	6.2 6.2	1-1/2-in.	\$33.00	2 2	Jig refuse chutes	11/15/75 (#2) 9/4/76 (#1)	6/23/77	Pad in #2 has worn spot at center.
		9.0	1-1/2-in.	\$33.00	6	Head end of 7xl-1/4 clean coal belt	12/17/75	9/4/76	Pad worn through at center; replaced with Trelleborg.
Trelleborg	VP plate profiled trellex 60	9.0	2-3/16-in.	\$66.00	4	Head end of 7xl-1/4 clean coal belt	9/4/76	6/23/77	Pad worn out at center.
		32.0	2-3/16-in.	\$46.00	14-1/2	Infeed to Grundlach clean-coal crushers	6/5/76	6/8/76	Trelleborg removed due to blockage; chute too shallow
		6.8	2-3/16-in.	\$43.00	4	Head end of crushed coal belt	9/9/76	6/23/77	Pad in good condition.
McBride Industries	Urethane	27.5	1-in.	\$22.00	7-1/4	Discharge chute from Re-use Desanding shaker	12/8/75	6/23/77	Pad still serviceable.

¹Based on average cost of 2-3/16-in. Trelleborg VP plate used at GPP; cost/sq ft varies with required precutting by supplier.

²Based on average cost for horizontal and vertical pads.

³These pads were previously installed at Grundlach Crusher infeed.

these treatments. While the noise reduction provided by these pads varies with each installation, experience at the Georgetown Plant indicates that 10 dB of *impact* noise reduction can be achieved.

The impact angle (i.e., the angle between the trajectory of the impacting material and the pad's surface) has a significant affect on the wear life of the pads. The service life of the resilient pads is optimized when the impact angle can be held at or near 90°. In several installations, the resilient pads actually outlived the original mild steel plates and compensated (on a cost/ton basis) for their high initial cost. The material costs for the resilient impact pads used in this project varied widely, depending on the type and installation. The average installation time for these pads ranges from 1 to 3 sq ft per man-hour.

The chute liners used experimentally in this project are summarized in Table E.5. Both resilient (primarily for noise reduction) and rigid (primarily for increased service life) liners have been used. The resilient (rubber) materials provided the most noise reduction (6 to 10 dB in closed chutes, 1 to 2 dB in open-top chutes), while the rigid materials (ceramics and plastics) provided the least. Noise reduction for the rigid materials is accomplished by reducing the vibration of the chute walls (through stiffening, addition of mass, etc.), which can radiate a significant amount of noise. These chute liners are of limited usefulness in open-top chutes for noise reduction, however, since the direct radiation of impact noise can often exceed 90 dB(A) alongside such chutes.

The chute liners ranged in cost from \$6 to \$10 per sq ft and, except for the Minaloy plastic, it is too early to judge overall service life. The Minaloy wore rapidly under impacts

TABLE E.5. SUMMARY OF CHUTE LINING MATERIALS USED AT THE GEORGETOWN PREPARATION PLANT.

Manufacturer	Description		Amount of Material Used	Cost	Location	Installation Date	Final Inspection Date	Comments
	Composition	Material Thickness		\$/Sq Ft				
Goodyear	Armaplate, 60 durometer rubber bonded to 16-gauge steel	1/2-in.	120 sq ft	\$ 5.60	Discharge end of secondary shakers	9/23/76 #2 11/6/76 #1	6/23/77	Armaplate worn out.
Workman Developments	Minaloy high molecular weight plastic	1/2-in.	52 sq ft	\$ 9.00	#2 Jig Refuse Chute	12/8/75	2/20/76	Removed due to excessive wear in spots (gouging).
Carborundum	Durafrax alumina (ceramic)	1/2-in.	80 sq ft	\$10.10	Jig Refuse Chutes	2/21/76 #2 9/25/76 #1	6/23/77	Liner in good condition; some cracks evident.
Workman Developments	Minaloy high molecular weight plastic	1/2-in.	2 x 120 sq ft	\$ 9.00	Cone desanding screen discharges	9/30/76 9/22/76	6/23/77	Slight wear patterns evident on sliding sections; one worn area at impact point in Hopper.
Goodyear	Armaplate, 60 durometer rubber bonded to 16-gauge steel	1/2-in.	50 sq ft each chute	\$ 5.60	Discharge chutes of Ripl-Flo screens	12/11/76 #5 1/8/77 #3	2/22/77	Chute liner in good condition.
Goodyear	Jade green armabond 60 durometer rubber	1/2-in.	50 sq ft each chute	\$ 5.90	Discharge chutes of Ripl-Flo screens	12/18/76 #4 1/22/77 #6	2/22/77	Chute liner in good condition.
Workman Developments	High molecular weight plastic	1/2-in.	~240 sq ft	\$ 9.00	Bottom pan of classifying screen	12/9/76	6/23/77	No wear visible, as yet.

from falling or bouncing material, which tended to gouge the plastic. In terms of wear, its most successful installation appears to be the discharge section of slow-speed shakers, with relatively smooth flow.

Lead-vinyl curtains were installed around a variety of equipment in the Georgetown Plant (see Table E.6) to reduce the noise radiated to adjacent aisles and walkways. While the noise reduction that can be achieved with this treatment depends heavily on the care with which the curtains are installed, 6 - 10 dB(A) of reduction was typical of the better installations. Since they do not directly affect production (as do some noise control treatments, such as resilient screens), and are less restrictive with respect to access for maintenance and repair than rigid enclosures, there are many situations where lead-vinyl curtains are an attractive noise control solution.

The curtains installed in the Georgetown Plant were primarily 3/4 lb/sq ft with smooth lead-vinyl layers on both sides. The average installed cost of the seven installations in this project was \$4.50/sq ft.

E.4 Program Effectiveness

The results of the noise control program at the Georgetown Plant are summarized in Table E.7, which presents a comparison between the A-weighted sound levels before and after the installation of the noise control treatments. Note that some of the noise reductions are estimated, either on the basis of measured levels close to the noise source or measurements on other similar installations in the plant. Since the measurement positions are typically operator or aisle positions, some of them are affected by the noise of several pieces of equipment. In those cases,

TABLE E.6. SUMMARY OF CURTAIN INSTALLATIONS.

Location	Curtailed Area (sq ft)	Curtain Manufacturer	Approximate Total Cost	Typical Noise Reduction Achieved (dB)
Secondary sizing screens	1500	Singer Partitions	\$7100	4 ³
Middling vibrators	450	Durocote	\$1100 ¹	7
Clean-coal desanding screens	>570	Singer Partitions	\$2700	3 to 4 ²
Ripl-Flo screen feed conveyor	750	Singer Partitions	\$3300	4 to 6
Grundlach clean-coal crushers	1350	Singer Partitions	\$6400	6
Wemco dryers	1100	Singer Partitions	\$4700	6
Reineveld dryers	4100	Singer Partitions	\$18900	10

¹Based on previous costs.

²Addition of ceiling baffles can provide 2 to 3 dB more reduction.

TABLE E.7. SUMMARY OF SOUND LEVELS MEASURED BEFORE AND AFTER TREATMENT.

Measurement Position	Associated Equipment	Measured Sound Levels, dB(A)		
		Before Treatment	After Treatment	Noise Reduction
A ₁	Belt Drives	92	90 - 92 ¹	0 - 2
A ₂	Primary Shaker	94	91 ¹	3
A ₃	Picking Table	94	90 - 92	2 - 4
A ₄	Boney Coal Crusher	93	91	2
B ₁	McLanahan Rock Crusher	93 - 100	91 - 92	2 - 8
B ₂		92	93	+1 ²
C ₁		92	95	+3 ²
D ₁	Secondary Sizing Screens	96	--	1 - 2 ³
D ₂		95 - 97	--	1 - 2 ³
D ₃		97	93	4 ⁴
E ₁	McNally-Baum Jigs	95	92 - 93	2 - 3
E ₂		97	91 - 93	4 - 6
E ₃		94 - 95	91	3 - 4
F ₁	Middling Vibrators	96	92	4
F ₂		95	93 - 94	1 - 2
F ₃		94 - 97	92	2 - 5
G ₁	Clean-Coal Desanding Shakers	96 - 97	93	3 - 4 ⁴
G ₂		96	95	1
H ₁	Ripl-Flo Screen Feed Conveyor	95	92 - 93	2 - 3
H ₂		94	91	3
H ₃	Dryer Feed Conveyor	90	--	--
I ₁	Grundlach Crushers	96	90	6
I ₂		--	--	--
J ₁	Ripl-Flo Screens	101	--	6 - 7 ⁵
J ₂		100	--	6 - 7 ⁵
K ₁	Vacuum Pump	95	--	--
L ₁	Refuse Desanding Shaker	97	95	2
M ₁	Reineveld Dryers	97 - 101	89 - 90	8 - 11
M ₂		99 - 103	91 - 92	8 - 11
N ₁	Jig Blowers	99	92 - 93	6 - 7
P ₁	Wemco Dryers	95	--	--
P ₂		96	--	--
P ₃		96	90	6
Q ₁	Head End Crushed Coal Belt	100	91 - 94	6 - 9
Q ₂	Classifying Shakers	102	96 - 97	5 - 6
Q ₃		104	--	--
Q ₄		103 - 104	--	--
R ₁	Jig Feeder	96	96	0 ⁶
S ₁	Rail Car Unloader (Shakeout)	111 - 113	--	-- ⁷
T ₁	Syntron Feeders	--	--	--

¹Resilient screen decks since removed.²Apparent change in crusher action.³Estimated, see text, pg. 3-34.⁴Additional curtain baffles at ceiling planned, 3 dB more deduction possible.⁵Estimated based on close-in measurements, screens since removed.⁶No specific treatments in this area.⁷Previous measurements indicate sound levels within operator booth were less than 90 dB(A); some deterioration in booth noticeable.

large noise reductions on a piece of equipment may be obscured by a more modest noise reduction on an adjacent piece of equipment (e.g., the effect of the McNally jigs on the apparent noise reduction of the middling vibrators). Table E.7, therefore, is more indicative of the noise reduction realized by the worker's exposures.

In terms of the effect of this noise control program on the plant operation, blinding of resilient screen decks represents the major operational problem. In the only two instances where resilient impact pads have caused problems, they were installed in too shallow a chute. Some additional effort is required to monitor visually those pieces of equipment enclosed by curtains, but not to the extent that the monitoring hampers the overall operation of the plant.

While noise reduction in coal preparation plants is difficult to achieve and maintain, significant, measurable amounts of noise reduction have been obtained at the Georgetown Preparation Plant without major adverse effects on productivity.

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1. INTRODUCTION

1.1 Background

Worker noise exposure in coal preparation plants has long been recognized as a serious problem. At least one previous study [1] has documented noise levels in the working areas of such plants to be consistently above 90 dB(A), and, in some cases, above 100 dB(A). To protect workers from permanent hearing damage, the Coal Mine Health and Safety Act of 1969 (CMHSA) has established 90 dB(A) as the maximum sound level to which a worker may be exposed for 8 hours per day on a regular basis. Exposure to sound levels in excess of 90 dB(A) is permitted, provided that the exposure period is reduced in accordance with the current standard [2].

Efforts to comply with the CMHSA noise standard have prompted:

- Substantial work on the identification and classification of the major noise sources in preparation plants, and
- The development and marketing of noise control materials for the mining and ore-processing industry.

Lacking, however, has been a quantitative study of the *benefits and limitations* of commercially available noise control materials within the operational environment of a coal preparation plant. What works and what doesn't work? Why? What are the useful service life, acoustic performance, maintenance requirements, and cost of a treatment?

This project was conducted to provide preparation plant operators answers to these questions, so that they can make informed, cost-effective decisions about the control of noise in their own plants.

1.2 Project Summary

Work on the project proceeded in the following steps:

- Selection of a demonstration plant
- Plant survey to document existing sound levels and operational procedures in working areas
- Characterization of major noise sources
- Selection and design of noise control treatments
- Installation and evaluation of treatments.

Two criteria determined the choice of the demonstration plant. First, the plant must be "typical"; i.e., its equipment, processes, and personnel assignments must be representative of the industry at large, so that the results of the study will be applicable to the industry. Second, all levels of plant personnel must cooperate in the project so that treatments will be installed and maintained properly and that accurate records will be kept of installation procedures, operational difficulties, and costs. On the basis of these criteria, Consolidation Coal Company's Georgetown Preparation Plant in Cadiz, OH was selected for this demonstration project.

A complete description of the separation processes, physical characteristics and capabilities of equipment, and personnel assignments for this plant is given in Sec. 2.

The design of noise control treatments was based on an analysis of the information obtained during the initial noise and operational survey. Primary constraints placed upon the designs were reasonableness of cost, worker access to equipment, maintenance requirements, and production efficiency, *as well as the development of useful information on a variety of techniques and*

materials. The treatments installed fall into four basic categories:

- Resilient impact pads
- Lead-vinyl curtains
- Chute liners
- Resilient screen decks.

Section 3 of this report describes the sound level survey, the equipment selected for treatment, and the noise control treatments installed. A set of floor plans for the plant and a more detailed discussion of the results of the sound level survey are included in Appendices A and B, respectively.

1.3 Results

The initial plant survey indicated that several of the plant workers' noise exposures exceeded CMHSA limits.

The installation of the noise control treatments has made a noticeable and significant reduction in the plant noise levels. This was accomplished, in most cases, without adversely affecting either the productivity or access to the equipment for maintenance or repair. In some cases (primarily resilient impact pads), the treatment has actually increased a unit's service life. The noise reductions achieved have resulted in real reductions in many of the workers' noise exposures. A quantitative evaluation of the program's effectiveness is presented in Sec. 4, together with recommendations for application to other plants and future research.

Since the individual treatments varied widely with respect to noise reduction, service life, and cost, this information is given on a treatment-by-treatment basis in Appendix C. A list

of the materials used in this project, with the names of their manufacturers, is given in Appendix D.

2. DEMONSTRATION PLANT

The Georgetown Preparation Plant in Cadiz, OH was selected for use as the demonstration plant for this noise control project on the basis of the criteria specified in Sec. 1.2.

The physical layout and processing circuits of the Georgetown Plant, as well as the personnel assignments, are described in this section of the report.

2.1 Process Description

The Georgetown Preparation Plant is shown in Fig. 1. Built in 1951, it processes approximately 1650 tons per hour (tph) of raw coal, from both surface and underground mines. Because of differences in mining techniques, coal from the underground mines typically is of smaller average size than the coal from the surface mines. As a result, the Georgetown Plant receives a relatively wide size distribution of raw coal.



FIG. 1. PHOTOGRAPH OF GEORGETOWN PREPARATION PLANT.

Because of its capacity and raw coal size distribution, the plant was designed with three distinct processing (or cleaning) circuits. Each of these circuits processes a specific range of coal size:

- 3/8 in. diameter or smaller (3/8 × 0 circuit)
- 3/8 in. to 1½ in. (1½ × 3/8 circuit)
- 1½ in. to 7 in. (7 × 1½ circuit).

These three circuits utilize the three types of mechanical cleaning equipment that are typically used in preparation plants (water tables, dense or heavy media separators, and water jigs) and that accounted for approximately 95% of the total tonnage processed in 1972 [1].

Figure 2 is a schematic of the coal flow through the plant. Raw coal from trucks and rail cars is dumped into storage bins at the plant. Rail cars are unloaded by either a 35-hp car shaker or a McDowell-Wellman rotary dump. The plant also receives coal from one underground mine via belt conveyor. Belt conveyors transfer the coal from the storage bins to the top floor of the plant where the separation and cleaning processes begin. Here, the primary shaker screen (1) separates the coal into two sizes — larger than 7 in. (plus 7 in.) and smaller than 7 in. (minus 7 in.).

Material that is over 7 in. in diameter passes over the top of the primary screens and is fed to a picking table, where the coal is separated from the refuse by hand. Rocks from the picking table (about 50 tph) drop into a McLanahan double-roll rock crusher and from there drop through a set of steel chutes to the main refuse belt, which carries the refuse to an exterior storage pile. The plus-7-in. coal (up to 5 tph) is sent either directly

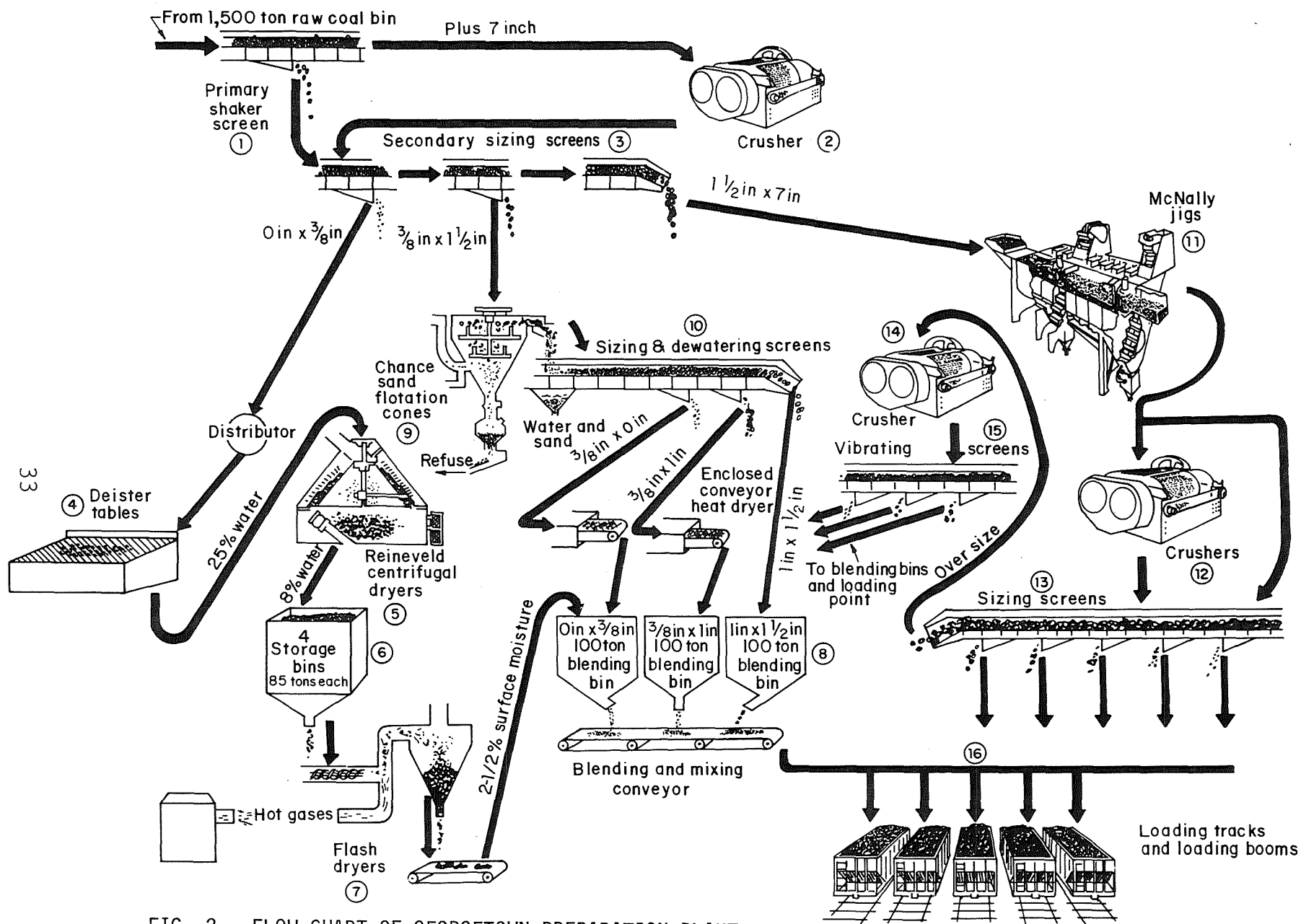


FIG. 2. FLOW CHART OF GEORGETOWN PREPARATION PLANT.

to the loadout plant or through a coal crusher ② prior to being sent to the secondary screens ③.

The secondary sizing screens receive coal from two sources: crushed coal from the coal crusher and the minus-7-in. raw coal that passed through the holes in the primary sizing screen. This pair of double-deck sizing screens separates approximately 1600 tph of coal into the three basic sizes processed by the plant, thereby dividing the flow into the three circuits.

2.1.1 3/8 × 0 in. circuit

Coal with a diameter of less than 3/8 in. falls through the smallest holes in the secondary sizing screens ③ and is distributed via a water flow to 32 Deister tables ④ for cleaning. The Deister tables, which are actually vibrating inclines, use gravity and mechanical action to perform the cleaning process. Since the coal is lighter than the refuse, it floats across the table, while the heavier refuse drops into a refuse trough. The wet coal leaving the tables contains approximately 7% ash.

From the Deister tables, the clean coal (approximately 320 tph) travels to 7 Reineveld centrifugal dryers ⑤ that reduce the moisture content of the coal from 25% to 8%. The coal drops to the bottom of the dryers and is sent to storage bins ⑥ prior to the final drying. At the present time, 4 Raymond flash dryers ⑦ are used to reduce the final moisture content in the coal to approximately 2.5%. From these dryers, the coal is conveyed to storage bins ⑧ in the loadout plant.

2.1.2 1½ × 3/8 in. circuit

Coal with a nominal diameter between 3/8 in. and 1½ in. drops through the secondary sizing screens ③ to a pair of Chance Sand

Flotation Cones (9). These 16-ft 6-in.-high cones are filled with a sand and water solution whose specific gravity is maintained higher than that of the incoming coal. Agitators within the cones keep the sand in suspension and assist in the separation process. Approximately 500 tph of clean coal floats over the top of the cones and is discharged to a pair of clean coal sizing and dewatering screens (10).

These screens separate the coal into three sizes (less than 3/8 in., 3/8 in. × 1 in., and 1 in. × 1½ in.), while water jets remove the sand that has adhered to the coal. The reclaimed sand is eventually returned to the cones. The two smaller sizes of coal are dried by Wemco centrifugal dryers, while the larger size is dewatered by drainage and sent directly to the storage bins in the loadout plant.

Refuse (about 175 tph) drops to the bottom of the chance cones and is sent to a refuse desanding and dewatering screen, where again the sand is reclaimed. The rock drops to the refuse belt, mentioned previously, and is carried out of the plant. A "middling product" (coal with large-scale impurities imbedded in it) is discharged from the center sections of the cones and screened separately before loadout.

2.1.3 7 × 1½ in. circuits

Coal sized between 1½ in. and 7 in. in diameter flows over the secondary sizing screens (3) to a pair of McNally-Baum coal jigs (11), which process approximately 400 tph of raw coal. Water bath separators in these jigs uses pulsating water jets to separate clean coal from middlings and refuse. Refuse (approximately 35%) falls to the bottom of the jigs, where it is dredged up and dewatered by vertical basket conveyors. Each basket, as it reaches

the top of its travel, successively dumps its refuse into chutes leading to the refuse belt. A middling product, which drops to a different portion of the jig bottoms, because of a difference in specific gravity, is also dredged up by basket elevators. These middlings can then be crushed and recirculated through the secondary sizing screens.

Approximately 260 tph of clean coal float over the dams at the far end of the jigs, are dewatered by a Jeffrey bar screen, and are sent to the loadout plant. At the loadout plant, the clean coal is either crushed by one of four Grundlach coal crushers (12) or sent to a classifying screen (13), which performs the final sizing before shipment. Oversize coal from these screens can be sent to another crusher (14) and eventually to 7 Allis-Chalmers Rip1-Flo (TM) sizing screens (15). From here, coal is transferred to the storage bins (8), which receive clean coal from the other circuits as well.

2.1.4 Loadout plant

The coal that drops through the classifying and Rip1-Flo screens can be distributed directly to any of the five loading booms (16) by a series of chutes and flighted steel chain conveyors. The clean coal is finally loaded into rail cars, which pass through the ground floor of the loadout plant, for shipment.

The loadout plant itself was designed for the maximum flexibility and control of product size. While this system allows the loadout operator to draw from any of the storage bins or sizing screen outputs to obtain the product size distribution required by the customer, the result is a large number of chutes, crushers, and screens - all of which generate a substantial amount of noise.

2.2 Equipment Location

Physically, the Georgetown Plant is composed of three contiguous buildings. Building A contains the coal infeed and cleaning equipment: raw coal belts, primary and secondary screens, McNally-Baum jigs, and Chance Cones. Building B houses the dewatering and desanding equipment, as well as the dryers and furnaces. The Deister tables, which clean the fine coal, are also located in Building B. Building C (the loadout plant) contains the final sizing and loading facilities, the clean coal crushers, and the storage bins. Although there is some overlap, each building generally contains the production equipment for a different phase of the overall cleaning process.

Table 1 lists the major equipment in the plant and its location in terms of building and level. Detailed floor plans for each level, which show the measurement positions used in the sound level survey as well as equipment locations, are presented in Appendix A. Note that Level 1 is the top floor of the plant, and it is here that the raw coal enters the plant in Building A.

2.3 Personnel Assignments

The plant personnel can be categorized as either stationary or mobile workers. The stationary workers are primarily specific equipment operators, who remain in a single location (or small area) for the majority of their shift on a day-in/day-out basis. These stationary workers include:

- Picker, who is located at the picking table on Level 3 of Building A, and hand sorts the plus-7-in. coal and rock coming off the primary screens (Location A₃).
- Wash Box Operator, who operates the McNally-Baum coal jigs (Location E₃).

TABLE 1. LOCATIONS OF MAJOR EQUIPMENT.

Equipment	Location		Sound Survey Measurement Positions (See Appendix A)
	Building	Level	
Belt Drives	A	1	A ₁
Primary Shaker Screen	A	1, 2	A ₂
Picking Table	A	3	A ₃
McLanahan Rock Crusher	A	3	B ₁ , C ₁
Boney Coal Crusher	A	3	-
Secondary Sizing Screens	A	4	D ₁ , D ₂ , D ₃
McNally-Baum Jigs	A	5	E ₁ , E ₂ , E ₃
Middling Screens	A	5	F ₁ , F ₂ , F ₃
Crop Belt & Discharge	A	4, 5	-
Chance Sand Flotation Cones	A	5, 6	-
Clean Coal Desanding Screens	B	5	G ₁ , G ₂
Ripl-Flo Feed Conveyor	B, C	5	H ₁ , H ₂
Dryer Feed Conveyor	B	5	H ₃
Grundlach Coal Crushers	C	5	I ₁
Jeffrey Feeder	A	5 1/2	-
Ripl-Flo Screens	B, C	5 1/2	J ₁ , J ₂
Vacuum Pump	B	5	K ₁
Classifying Screens	C	6, 7	Q ₂ , Q ₃ , Q ₄
Middlings Crusher	A	6	R ₁
Flash Dryers	B	6	-
Cone-Refuse Desanding Shaker	A	7	L ₁
Reineveld Dryers	B	7 1/2	M ₁ , M ₂
Deister Tables	B	7	-
Wemco Dryers	B	7	P ₁ , P ₂
Rotary Rail Car Dump	-	-	S ₁
Rail Car Shakeout	-	-	S ₁
Jig Refuse Shaker	A	6	

- Panel Board Operator, who operates the flash dryer furnaces (Level 7, Building B).
- Deister Operator, who spends the majority of his shift either at the control panel for the Deister tables (Level 7, Building B) or at the Reineveld Dryers (Level 7½, Building B).
- Loadout Operator, who operates the control room in the loadout plant and controls the loading of the clean coal into rail cars (Level 7, Building C).
- Car Shakeout Operator, who operates the rotary and shakeout rail car unloaders (Rail Car Unloading Area).
- Warehouse Tender, who is located in the warehouse office (Level 5, Building A).

The mobile workers, or those who do not remain at the same position for extended lengths of time on a day-after-day basis, include:

- 6 mechanics (on the day shift)
- 4 clean-up workers
- 1 pan line worker
- 1 oiler
- 1 sampler
- 2 coal inspectors, who spend most of their time in the loading plant
- 2 electricians
- 1 master mechanic
- 1 plant foreman.

The Georgetown Preparation Plant normally processes coal from 7:15 a.m. to 2:30 p.m., with a midday shutdown of 30 minutes for lunch. The scheduled operation time is therefore $6\frac{3}{4}$ hours per day. Between January 1975 and October 1976, the plant averaged 6 hours and 22 minutes of actual operation per day. According to the present CMHSA standard, the allowable continuous sound level for this daily exposure time is between 91 and 92 dB(A).

3. NOISE CONTROL PROGRAM

3.1 Plant Survey

A plant survey was conducted to identify (1) the major noise sources in the plant and (2) worker exposure to these sources, and thereby identify the areas where noise control was required. In addition, the survey included operational information that defined the restrictions on the design of noise control treatments - for example, where physical access to equipment is required and where visual monitoring is necessary. The survey also provided baseline noise levels for comparison with noise levels measured after noise control treatments had been installed.

In each area of the plant, the A-weighted overall sound level for various operating conditions was measured with a hand-held sound level meter. In those areas where the combination of high sound levels, ordinarily above 90 dB(A), and worker exposure periods was such that noise control might be required, additional measurements were made. These additional measurements consisted of direct readings of the octave-band sound spectra, as well as magnetic tape recordings that were later analyzed in the laboratory with the aid of a real-time analyzer. Where it was evident that vibration constituted a significant part of the problem, tape recordings of the acceleration levels were also taken for subsequent laboratory analysis. A detailed discussion of the survey data is presented in Appendix B.

Table 2 summarizes the results of the noise survey. Listed in this table are:

- The equipment categories identified as being major noise sources.

TABLE 2. SUMMARY OF MEASURED SOUND LEVELS.

Equipment	Measurement Position	Measured Sound Levels, dB(A)		
		Full Capacity	No-Coal [1]	No-Coal (Alone) [2]
Belt Drives	A ₁	92	88 - 91	85
Primary Shaker	A ₂	94	90 - 94	90 - 92
Picking Table	A ₃	94	91	88
Boney Coal Crusher	A ₄	93	90	86
McLanahan Rock Crusher	B ₁	93 - 100	91	71
	B ₂	92	89	78
	C ₁	92	90	77
Secondary Sizing Screens	D ₁	96	88	79
	D ₂	95 - 97	87	76
	D ₃	96	--	--
McNally-Baum Jigs	E ₁	95	92	81
	E ₂	97	92	83
	E ₃	94 - 95	--	--
Middlings Vibrators	F ₁	96	--	88
	F ₂	95	--	93
	F ₃	94 - 97	--	86
Clean Coal Desanding Shakers	G ₁	96 - 97	92	80
	G ₂	96	92	84
Ripl-Flo Screen Feed Conveyor	H ₁	95	92	80
	H ₂	94	91	80
Dryer Feed Conveyor	H ₃	90	--	--
Grundlach Crushers	I ₁	96	86	80
	I ₂	--	85	80
Ripl-Flow Screens	J ₁	101	97	96
	J ₂	100	95	96
Vacuum Pump	K ₁	95	96	92
Refuse Desanding Shaker	L ₁	97	96	94
Reineveld Dryers	M ₁	97 - 101	95	92
	M ₂	99 - 103	95	92
Jig Blowers	N ₁	99	100	102
Wemco Dryers	P ₁	95	92	--
	P ₂	96	--	--
	P ₃	96	--	--
Head End Crushed Coal Belt Classifying Shakers	Q ₁	100	--	--
	Q ₂	102	--	92 - 94
	Q ₃	104	--	--
	Q ₄	103 - 104	--	--
Jig Feeder	R ₁	96	--	--
Rail Car Unloader (shake-out)	S ₁	111 - 113	--	--
Syntron Feeders	T ₁	--	108	--

[1] "No-Coal" refers to the operation of the equipment, in conjunction with adjacent equipment, without coal flow.

[2] "No-Coal (alone)" refers to the same operating condition as [1], except all adjacent equipment is shut down.

- The positions at which noise measurements of these equipment categories were made (see Appendix A).
- The A-weighted sound levels measured at these positions for various plant operating conditions - i.e., full capacity, no coal flow, individual equipment operating alone with no coal flow.

Note that some of the machines that were illustrated in Fig. 2 and listed in Table 1 were not identified as major noise sources. The classification of the major noise sources is discussed in Appendix B.

The reason for measuring the equipment under various plant operating conditions was to determine which noise sources were dominating the sound levels measured in each area. For example, the sound level beside the primary shaker screen (position A₂) was 94 dB(A) during normal operation and 90 to 92 dB(A) when the screen was operating alone with no coal, thus indicating that the noise caused by the impacts of the coal on the screen is typically 91 to 92 dB(A).

The sound level at the picking table operator's position (A₃) under full capacity conditions was generally 94 dB(A), with occasional peaks to 100 dB(A) as large rocks dropped into the McLanahan rock crusher infeed chute. The 88-dB(A) sound level measured at position A₃, with the picking table operating alone, indicates that the drive mechanisms are roughly equivalent to the background levels of the other nearby equipment and therefore not serious noise problems.

The noise levels of the secondary shaker drives, which are relatively slow-speed crank-arm mechanisms, were low [76 to 79 dB(A)] compared to the "no-coal" sound levels generated by equipment located in adjacent plant areas [87 to 88 dB(A)]. During

normal operation, the noise of coal/screen and coal/coal impacts [95 to 97 dB(A)] dominated at positions D_1 and D_2 .

The middling shaker screens and the McNally jigs, which are located adjacent to each other, both influence the noise exposure of the Wash Box Operator during normal operation. The sound levels in this area during full capacity operation ranged from 94 to 97 dB(A). Although the major sources were readily identified as the coal/screen impacts on the middling shakers and the impacts of refuse in the jig chutes, equipment in adjacent plant areas (such as clean coal desanding shakers, crop belt discharge, jig air and water noise, and coal impacts at the discharge of the middling vibrators) also contribute.

A comparison between the full operation and no-coal/operating alone sound levels for the clean coal desanding shakers in Building B [96 to 97 dB(A) and 80 to 84 dB(A), respectively] indicates the extent to which the noise of the coal/coal, coal/screen impacts dominated the sound field around these shakers. These impacts occur both on the screen surface and in the discharge chutes and bins.

The 3-dB difference in sound levels measured near the Rippl-Flo screen feed conveyor for full capacity and no-coal conditions is directly attributable to the noise reduction in adjacent equipment; i.e., the Rippl-Flo screens below and the desanding shakers across the aisle operate much more quietly when the coal flow ceases. The chain conveyor noise is due to the sliding of the chain and flights over the conveyor structure and is only slightly affected by the presence of coal.

Sound levels measured at the Grundlach coal crushers [80 dB(A) for no-coal conditions vs 96 dB(A) at full capacity] indicated that gearing was not a major noise problem in these units.

The Ripl-Flo screens, which are eccentric-weight, high-speed shakers (compared to the secondary sizing screens) generated appreciable noise [96 dB(A)] even without coal flow.

The refuse desanding shakers also generated appreciable noise, 94 dB(A) when operating alone/no-coal, indicating that the drive mechanisms were major contributors.

The sound levels by the 7 Reineveld dryers ranged from 97 to 103 dB(A). While the vibration from the dryer rotation alone contributed sound levels of 92 dB(A) during the initial survey, these levels can vary, depending on the condition of the dryer baskets.

Measurements in the Wemco dryer area indicate that the noise caused by the presence of coal flow increased the no-coal operating levels at position P₁ by 3 dB(A) to 95 dB(A).

The 100- to 104-dB(A) sound levels in the classifying screen area are primarily caused by coal/screen and coal/coal impacts. The sound levels at position Q₂ with the shaker operating alone/no-coal were 92 to 94 dB(A), and this noise was primarily bearing squeak.

The car shakeout generated 111 to 113 dB(A) during operation (which is not continuous), because of radiation of the hopper car sides, which are vibrated by the shaker mechanism. In addition, the noise levels tend to increase as the car is emptied.

3.2 Worker Noise Exposure

Although the actual noise exposure of plant employees varies with job requirements, the majority of the workers at the Georgetown Preparation Plant were exposed to sound levels in excess of 90 dB(A) for at least a portion of their workday. The exceptions

are the loadout operator, the furnace operator, the warehouse tender, and the foreman, all of whom are stationed in rooms isolated from the plant equipment.

Noise exposures of stationary workers result from the noise contributions of the limited number of machines in their work area and change only with changes in machine or plant operation. Noise exposures of the mobile operators, on the other hand, result from the noise contributions of all of the machines they encounter during their workday and vary with their daily routine, as well as with changes in plant operation.

Clearly, a noise exposure survey that indicates that only stationary workers are overexposed will have a different impact on the selection of noise control treatments than one indicating that mobile workers are overexposed. In the former case, noise control treatments, such as the use of booths, can be keyed to specific operators. Reduction of the mobile workers' exposures requires a different approach: the direct treatment of a number of pieces of equipment in different areas of the plant. In those instances, typical of most plants, where both types of workers are overexposed, direct treatment of equipment is often the better approach.

Table 3 lists some representative plant workers and their noise exposures prior to the noise control program. The exposure values, which were calculated from time studies of their work routine, indicate (as was expected) that both mobile and stationary workers were overexposed according to the CMHSA.

The procedure for determining the noise exposure for workers is based on calculating their Noise Exposure Coefficient, E:

$$E = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_n}{T_n} ,$$

TABLE 3. SUMMARY OF WORKER EXPOSURE DURING FULL CAPACITY OPERATION.

Job Title	Mobile (M), Stationary (S)	Noise Exposure Coefficient
Wash Box Operator	S	1.4
Picker	S	1.7 - 1.8
Loadout Operator	S	0.0
Deister Operator	S	1.5
Clean Up #1	M	2.3
Clean Up #2	M	2.2
Oiler	M	1.3
Mechanic (4)	M	[1.0]*
Foreman	S	[0.5]
Warehouse Tender	S	0.0
Master Mechanic	S	[0.5]

*Brackets enclose estimated values from partial observations.

where C_n represents the time an operator is exposed to a specified sound level and T_n is the exposure time permitted at that sound level. A noise exposure coefficient greater than 1.0 is considered to be a violation of current regulations.

3.3 Selection of Equipment to Be Treated

Equipment classified as a major noise source was selected for treatment on the basis of worker noise exposure as well as the desire for basic performance data on a variety of commercially available noise control materials. Areas of priority, based on worker exposure, were classified as follows:

Type I - Continuous-exposure area, in which at least one person is located for his entire shift.

Type II - Frequent-exposure area, in which personnel (mobile) are found 1/3 to 2/3 of their shift.

Type III - Limited-exposure area, in which personnel are found about one hour or less a day.

Classification of work areas in the plant into these three types of exposure classifications is described in Appendix B.

Table 4 lists the major noise sources in the plant, their representative sound levels, and the exposure classification of the areas in which they are located. The representative sound levels are either for the individual piece of equipment or for the area in which several pieces of equipment normally operate simultaneously and contribute to worker noise exposure. These sound levels, therefore, represent normal working conditions at full plant capacity and the noise levels to which workers are potentially exposed.

Those machines having high noise levels and Type I or II exposure classifications were considered high-priority sources and were selected for treatment.

3.4 Noise Control of Plant Equipment

In general, treatment of screens and chutes represents the core of the noise control program at the Georgetown Preparation Plant. In Sec. 3.3, screens were identified as major noise sources. Chutes, on the other hand, are associated with several of the equipment categories and are considered as part of other equipment items throughout this report. In this section, we discuss some general aspects of screens and chutes and then describe the four categories of treatments applied to the equipment identified in Sec. 3.3.

TABLE 4. NOISE SOURCES AND EXPOSURE CLASSIFICATIONS.

Equipment Description	Representative Sound Level in dB(A)	Exposure Classification
Oak Park Belt Drive	92 - 94	III
Rom Belt Drive	91	III
Primary Screen	94	II
Picking Table	94+	I
McLanahan Rock Crusher	Impulses to 100	I
Secondary Sizing Screens	95 - 97	II
McNally-Baum Jigs	94 - 97	I
Middling Shakers	94 - 97	I
Jeffrey 5 ft x 9 ft Feeders	95	III
Clean Coal Desanding Screens	96 - 97	II
Ripl-Flo Feed Conveyor	94 - 95	II
Dryer Feed Conveyor	90	III
Grundlach Coal Crushers (4)*	96	II
Ripl-Flo Screens (7)	101	II
Vacuum Pump	95	III
Cone Refuse Desanding Screen	97	III
Reineveld Centrifugal Dryers (7)	97 - 103	II
Wemco Dryers (6)	95 - 96	II
Classifying Screens	102 - 104	II
Rail Car Shaker	111 - 113	II
Flash Dryers	-	III
Middlings Crusher	-	III
Jig Refuse Shaker	96	III
Syntron Feeders	108	III
Jig Blowers	99	III

*Numbers in parentheses refer to the number of individual machines of each type in use.

3.4.1 General discussion of noise control treatments for screens and chutes

Screens

Screens can be classified into two categories according to the speed of their vibrating motion. Fast screens are usually driven by rotating eccentric weights at about 900 rpm (15 Hz); slow screens, by crank-arm mechanisms at about 200 rpm (3.3 Hz). The major sources of noise associated with both types of screens vary with the size and composition of the product flowing over the screen deck.

Even when operated without flow, fast screens typically generate significant noise, often in excess of 90 dB(A). Slow screens, on the other hand, are not normally noisy when operated without coal. The exception, however, is the slow-speed shaker, which has loose metal components that bang against each other or squeak when shaking. In these cases proper maintenance is required.

The collisions of coal and/or rock particles, as they travel along the screen deck surface, produce repetitive impact or impulsive sounds. The level of this impulsive noise depends on the volume, size, and hardness of the flow, the speed at impact, and the stiffness of the impacted screen. Generally, noise levels are higher for larger and harder particles, higher speeds at impact, and harder screen decks (steel). Thus, the need for noise control actually depends on the amount and type of product being screened and the type of screen being used, in addition to the worker exposure classification.

Previous experience has indicated that particle size must ordinarily be greater than 1/2-in. diameter for fast screens and 1-in. diameter for slow screens before coal impact noise exceeds 90 dB(A) alongside the screen. The influence of product hardness is to reduce these cut-off particle sizes. Thus, operations involving the screening of coal particles greater than 1/2-in. diameter (rock, 3/8-in. diameter) by fast screens and the screening of coal particles greater than 1-in. diameter (rock, 3/4 in.) by slow screens are typically candidates for noise control.

The first choice of treatments to control the noise of screening operations is resilient screen decks. These decks, which are normally interchangeable with the original steel decks, have a resilient top surface that distributes the impact in time and

space to absorb the impact energy. These screens are either a composite construction (a resilient layer bonded to a thin steel deck, or a combination of resilient layers of different hardness) or a deck of uniform resilient material.

The thickness of the resilient (elastomer) material must be carefully selected to provide a balance between offering a sufficiently thick layer to prevent the elastomer from being compressed excessively (pinched) when impacted, and offering a layer that is so thick that it causes excessive blinding (plugging of holes). In general, to prevent pinching and surface gouging use:

- 3/8-in.- to 1/2-in.-thick resilient layers for particles from 1/2 in. to 2 in. in diameter
- 3/4-in.- to 1-in.-thick for particles between 3 in. and 7 in. in diameter.

It is difficult to establish, universally, the maximum thickness feasible before excessive blinding sets in, because different flows have different tendencies to blind. However, flows containing a significant amount of fine granular particles and moisture have a greater tendency to blind than do more uniform flows, because the small wet particles tend to "pack" around the larger pieces as they become lodged in the screen holes and prevent these pieces from working their way through the holes. Also, flows that have a large percentage of "near size" particles (i.e., pieces with a nominal diameter equivalent to the screen hole diameter) have higher blinding potential. A useful rule-of-thumb is that the thickness of the resilient material should not be greater than the size of the holes in the screen. One final point is that slow-speed crank-arm shakers generally have a greater potential for blinding problems than high-speed eccentric weight units because of the lower acceleration levels of the crank-arm units.

Chutes

Chutes can be classified into two categories - closed and open. The dominant source of noise in closed chutes is the impact of coal and rock on the chute walls, which reradiate the resulting vibration as sound. In open chutes, noise radiating directly from sliding, rolling, and bumping of product flow is the more important problem.

Reducing the noise radiated from closed chutes requires a reduction in either the impulsive forcing or the resulting vibration of the chute plates. A resilient layer at the impact point will reduce the impulsive forcing, and adding mass, stiffness, or damping to the vibrating chute plates will reduce their vibration.

Design problems encountered with resilient impact pads or chute liners center on providing a wear surface that will withstand the impacting or abrasion of the coal and rock, and on the relationship of material thickness to the size, hardness, and velocity of the impacting particles.

Adding mass (weight) at the impact point, to reduce the chute vibrations, can be accomplished by using steel bars or rails on outer walls, a castable material at the back of the chute wall, or a steel wear plate at the impact point. In some cases, stiffness can also reduce chute wall vibration and can be provided by ceramic or plastic wear liners inside the chute. Damping can be added to the chutes by the application of one of the damping materials currently on the market to the outside of the chute wall. A more complete discussion of these materials, which are available in either sheet or paste form, is given in Ref. 3. The noise reduction, however, will generally be less than that provided by resilient liners.

Incorporating stone boxes or deflector plates in vertical chutes also has the potential for reducing chute noise by dividing a single large drop height into several smaller drop heights and thereby reducing the impacting velocity (which influences noise generation) of the particles. Stone boxes, which tend to accumulate a layer of crushed material on their bottom surface, have the added benefit that this material is a constantly renewed (inexpensive), relatively resilient impact absorber. For a more detailed discussion of such treatments, see Ref. 3.

Note, then, that:

- In general, for product flow that drops 4 to 5 ft, the resilient layer should be at least 1-in. thick for coal or rock sizes up to 2-in. diameter and at least 1½-in. thick for sizes up to 7 in.
- For larger sizes or higher drops, thicker layers are required. Manufacturers can generally provide such design information for their materials.

The service life of resilient materials also depends very much on the angle at which the flow strikes it. The wear resistance of most resilient materials is greatest when this angle is greater than 60° (ideally 90°). When the angle of impact is less than 60°, then a stepped resilient material can be used to restore the installation to a near 90° impact angle. Impact angles of less than 10° will also adversely affect all resilient liners and may require special treatment.

3.4.2 Summary of treatments and costs

The noise control treatments installed at the Georgetown Preparation Plant will be discussed in four general categories:

- Resilient screen decks
- Resilient impact pads
- Chute liners
- Curtains.

Resilient Screen Decks

Resilient screen decks, either composite or all-resilient decks, have the potential for providing 7 to 9 dB of reduction in coal/screen impact noise. Actual achievement of such reductions at typical worker locations alongside the screens may require treatment of the noise generated at the infeed and discharge chutes, bottom pan, and the drive mechanism (for high-speed shakers), in addition to the treatment of the screen noise itself.

The drawbacks of such screens can be summarized as follows:

- *Initial cost.* The resilient screens installed at the Georgetown Plant cost from 3 to 6 (typically 3 to 4) times their steel counterparts.
- *Blinding.* In the resilient screens installed at the Georgetown Plant, blinding varied from 10% to 70%, with the thick, all-resilient material decks more prone to blinding than the thinner composition decks. Slow-speed crank-arm shakers were more susceptible to such problems than the eccentric-weight vibrating units.
- *Separation.* In several of the composition decks (resilient layer bonded to steel), the resilient layer separated from the steel. Separation, which appeared to be the primary mode of failure in these decks, prevented a true assessment of the actual abrasive wear characteristics of the screens.

While the initial installation time for these decks ran up to $2\frac{1}{2}$ times the *replacement* time for the original steel decks, owing to required modifications in the mounting brackets, etc., the *replacement* time for these decks should be more comparable to that for the steel decks.

Table 5 summarizes the resilient screen decks installed at the Georgetown Plant.

Resilient Impact Pads

Both ribbed (profiled) and flat resilient impact pads were installed at the discharge ends of various belts, chutes, and screens to assess wear life as well as noise reduction. The results indicate that when the impact angle (i.e., the angle between the direction of the flow and the surface of the pad) was approximately 90° , the service life of these pads can actually exceed the original steel plates. In some cases, this extended wear life has (on a cost/ton basis) compensated, somewhat, for the high initial material costs. With less than optimum impact angles, service life is significantly reduced. The results at this demonstration plant indicate that pad thickness and impact angle are potentially more important to the overall wear life than the material-to-material (e.g., rubber to urethane) differences.

While the noise reduction afforded by these pads varies with each installation, experience at the Georgetown Plant indicates that 10 dB of *impact* noise reduction is not unreasonable. Installation time for the impact pads depends on the material (whether it must be cut with special equipment), the accessibility of the installation, and, to a lesser extent, the amount of materials to be installed. At the Georgetown Plant, installation times for

TABLE 5. SUMMARY OF RESILIENT SCREEN USAGE AT THE GEORGETOWN PREPARATION PLANT.

Manufacturer/ Supplier	Description					Cost		Location	Installation Date	Final Inspection Date	Comments
	Hole Size (in.)	Steel Thickness (in.)	Rubber Thickness (in.)	Composition	Panel Size (in.)	\$/Sq Ft	Cost Factor*				
Laubenstein	6	1/2	1/4	EAR C2003 bonded to bottom of steel deck	1-120x48	No Charge	--	Primary Shaker-4th screen from top	7/26/76	9/30/76	*50% of EAR material separated from steel.
Hewitt-Robins/ Laubenstein	6	3/8	3/8	"Tuffgard" bonded to steel deck (80 durometer)	4-60x48	32.50	3.5	Primary shaker-2nd & 3rd screen from top	7/12-14/76	9/30/76	*Resilient layer separating from steel at leading edges. *Removed on 11/11/76 due to blockage of coal flow.
McEride Industries	1-1/4	--	1-3/16	All urethane screen deck	1-94x48	25.00	4.3	Secondary shakers-2nd screen above crosshead on #2	11/18/75	12/17/75	*Removed on 12/17/75 due to excessive blinding.
Trelleborg	1-1/4	--	3/4	60 durometer rubber deck (Duenero)	1-94x48	37.00	6.3	Secondary shaker	10/18/75	10/31/75	*Removed on 10/31/75 due to excessive blinding.
	1-1/4	--	3/4	60 durometer rubber deck (Duenero)	1-94x48	No Charge	--	Secondary shaker	1/13/76	1/20/76	*This is same as previous screen, with a different clamping arrangement. *Removed on 1/20/76 due to excessive blinding.
Hendrick "Rubber Clad" Screens	1-1/4	3/16	3/8	60 durometer rubber bonded to steel	2-94x48	21.50	3.6	Secondary shakers	1/22/76	4/13/77	*7/13/76, leading edge of rubber beginning to separate from steel, one worn patch. *7/26/76, reversed screen. *Blinding ~10-15% *4/13/77 rubber worn away.
Hewitt-Robins/ Laubenstein	1-1/8 Hexag. Holes	3/16	1/4	"Tuffgard" bonded to steel deck	4-59x42 4-46x41	23.50	3.7	RIPL-FLO vibrators	9/17/76	2/22/77 6/23/77	*#1 screen showing some separation. Blinding 10-15% *#1 screen almost completely separated.
Linatex/ Laubenstein	1-1/2 Rubber 1-3/4 Steel	10 ga	3/8	60 durometer rubber bonded to steel deck	7-48x95	16.50	-2.7	Classifying shakers	11/29-30/76	6/23/77	Blinding ~60-70%.

$$\text{*Cost Factor} = \frac{\text{Cost of Resilient Deck}}{\text{Cost of Original Steel Deck}}$$

the range of installations were typically 1 to 2 sq ft per man-hour for Trelleborg-VP plate and 1½ to 3 sq ft per man-hour for the urethane. It should be noted that the material cost for the 2-3/16-in. Trelleborg-VP plate ranged from \$35 to \$65 per sq ft, depending on the amount of precutting and trimming that was done by the supplier. The average cost of the VP plate used in this project was \$48 per sq ft. The T-bolts used to fasten the Trelleborg to the chute walls cost \$3.50 each, and typically 1 per sq ft of material was used in the Plant.

Table 6 summarizes the impact pads installed at the Georgetown Preparation Plant.

Chute Liners

The chute liners used experimentally in this project are summarized in Table 7. Both resilient (primarily for noise reduction) and rigid (primarily for increased service life) liners have been used. The resilient materials (such as Goodyear Arma-plate and Jade Green Armabond) provided the most noise reduction (6 to 10 dB in closed chutes, 1 to 2 dB in open-top chutes), while the rigid materials provided the least. Noise reduction for the rigid materials is accomplished by reducing the vibration of the chute walls (through stiffening, addition of mass, etc.), which can radiate a significant amount of noise. These chute liners are of limited usefulness in open-top chutes for noise reduction, however, since the direct radiation of impact noise can often exceed 90 dB(A) alongside such chutes.

The chute liners ranged in cost from \$6 to \$10 per sq ft and, except for the Minaloy plastic, it is too early to judge overall service life. The Minaloy wore rapidly under impacts from falling or bouncing material, which tended to gouge the plastic. In

TABLE 6. SUMMARY OF RESILIENT IMPACT PADS INSTALLED AT THE GEORGETOWN PREPARATION PLANT.

Manufacturer	Composition	Area (Sq Ft)	Thickness	Cost/Sq Ft	Approximate Installation Time (Man-hours)	Location	Installation Date	Final Inspection Date	Comments
Goodyear	Armaplate-60-durometer rubber bonded to 16-gauge steel	2.0	1/2-in.	\$ 5.60	2	Picking table	1/29/76	11/6/76	Armaplate wornout; replaced with 1-1/2 in. urethane.
McBride Industries	Urethane	3.0	1-1/2-in.	\$33.00	2	Picking table	11/6/76	6/23/77	Pad in generally good condition, showing some wear.
Trelleborg	VP plate profiled trellex 60 with steel mounting channels	11.3	2-3/16-in.	\$48.00 ¹	10	Infeed to McLanahan Crusher	9/4/76 11/15/76	6/23/77	Both pads in good condition.
		14.3	2-3/16-in.	\$63.00 ²	--	Horizontal & vertical impact points in McLanahan discharge chute	8/21/76	8/22/76 11/27/76 4/13/77	Horizontal pad removed due to backup. Vertical pad replaced due to incorrect installation. Vertical pad slipped from mounting.
Goodyear	Armaplate	3.0	1/2-in.	\$ 5.60	4	Discharge of middling vibrators	9/30/76	6/23/77	Both pads in good condition.
Trelleborg	VP plate profiled trellex 60	9.0	2-3/16-in.	\$46.00 ³		Discharge of crop conveyor		6/23/77	Pads in good condition.
		18.3 13.3	2-3/16-in.	\$32.00 \$49.00	14-1/2 14-1/2	Discharge of jig refuse elevator	11/15/75 (#2) 6/19/76 (#1)	6/23/77	Pad in #2 in good condition.
McBride Industries	Urethane	6.2 6.2	1-1/2-in.	\$33.00	2 2	Jig refuse chutes	11/15/75 (#2) 9/4/76 (#1)	6/23/77	Pad in #2 has worn spot at center.
		9.0	1-1/2-in.	\$33.00	6	Head end of 7x1-1/4 clean coal belt	12/17/75	9/4/76	Pad worn through at center; replaced with Trelleborg.
Trelleborg	VP plate profiled trellex 60	9.0	2-3/16-in.	\$66.00	4	Head end of 7x1-1/4 clean coal belt	9/4/76	6/23/77	Pad worn out at center.
		32.0	2-3/16-in.	\$46.00	14-1/2	Infeed to Grundlach clean-coal crushers	6/5/76	6/8/76	Trelleborg removed due to blockage; chute too shallow
		6.8	2-3/16-in.	\$43.00	4	Head end of crushed coal belt	9/9/76	6/23/77	Pad in good condition.
McBride Industries	Urethane	27.5	1-in.	\$22.00	7-1/4	Discharge chute from Refuse Desanding shaker	12/8/75	6/23/77	Pad still serviceable.

¹Based on average cost of 2-3/16-in. Trelleborg VP plate used at GPP; cost/sq ft varies with required precutting by supplier.

²Based on average cost for horizontal and vertical pads.

³These pads were previously installed at Grundlach Crusher infeed.

TABLE 7. SUMMARY OF CHUTE LINING MATERIALS USED AT THE GEORGETOWN PREPARATION PLANT.

Manufacturer	Description		Amount of Material Used	Cost	Location	Installation Date	Final Inspection Date	Comments
	Composition	Material Thickness		\$/Sq Ft				
Goodyear	Armaplate, 60 durometer rubber bonded to 16-gauge steel	1/2-in.	120 sq ft	\$ 5.60	Discharge end of secondary shakers	9/23/76 #2 11/6/76 #1	6/23/77	Armaplate worn out.
Workman Developments	Minaloy high molecular weight plastic	1/2-in.	52 sq ft	\$ 9.00	#2 Jig Refuse Chute	12/8/75	2/20/76	Removed due to excessive wear in spots (gouging).
Carborundum	Durafrax alumina (ceramic)	1/2-in.	80 sq ft	\$10.10	Jig Refuse Chutes	2/21/76 #2 9/25/76 #1	6/23/77	Liner in good condition; some cracks evident.
Workman Developments	Minaloy high molecular weight plastic	1/2-in.	2 x 120 sq ft	\$ 9.00	Cone desanding screen discharges	9/30/76 9/22/76	6/23/77	Slight wear patterns evident on sliding sections; one worn area at impact point in Hopper.
Goodyear	Armaplate, 60 durometer rubber bonded to 16-gauge steel	1/2-in.	50 sq ft each chute	\$ 5.60	Discharge chutes of Ripl-Flo screens	12/11/76 #5 1/8/77 #3	2/22/77	Chute liner in good condition.
Goodyear	Jade green armabond 60 durometer rubber	1/2-in.	50 sq ft each chute	\$ 5.90	Discharge chutes of Ripl-Flo screens	12/18/76 #4 1/22/77 #6	2/22/77	Chute liner in good condition.
Workman Developments	High molecular weight plastic	1/2-in.	~240 sq ft	\$ 9.00	Bottom pan of classifying screen	12/9/76	6/23/77	No wear visible, as yet.

terms of wear, its most successful installation appears to be the discharge section of slow-speed shakers, with smooth, relatively slow flows.

Vinyl Curtains

Lead-vinyl curtains can provide between 6 and 10 dB of noise reduction in aiseways adjacent to the enclosed machinery. The reduction achieved is a function of the care with which the curtains are installed. The primary benefits of the curtains (in addition to the noise reduction provided) are (1) they do not directly affect production and (2) they restrict access for maintenance and repair less than solid enclosures. Their initial cost of \$4.50 per sq ft (installed) is expected to be offset by their projected service life. Also, vinyl windows and increased lighting can assist the visual monitoring of the equipment.

Singer Partitions curtains were used in most installations in the demonstration plant. These curtains, whose surface density is $3/4$ lb per sq ft, were composed of lead-vinyl layers on both sides. While this type of construction was selected to limit the coal dust accumulation on the curtains (compared to open cell foam-backed curtains), some sound buildup occurred on the noise source side of the curtain, increasing source sound levels by about 3 dB.

The areas where curtains have been installed at the Georgetown Preparation Plant are listed in Table 8.

TABLE 8. SUMMARY OF CURTAIN INSTALLATIONS.

Location	Curtained Area (sq ft)	Curtain Manufacturer	Approximate Total Cost	Typical Noise Reduction Achieved (dB)
Secondary sizing screens	1500	Singer Partitions	\$7100	4 ³
Middling vibrators	450	Durocote	\$1100 ¹	7
Clean-coal desanding screens	>570	Singer Partitions	\$2700	3 to 4 ²
Ripl-Flo screen feed conveyor	750	Singer Partitions	\$3300	4 to 6
Grundlach clean-coal crushers	1350	Singer Partitions	\$6400	6
Wemco dryers	1100	Singer Partitions	\$4700	6
Reineveld dryers	4100	Singer Partitions	\$18900	10

¹Based on previous costs.

²Addition of ceiling baffles can provide 2 to 3 dB more reduction.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Effectiveness of Program

Tables 9 and 10 summarize the results of the noise control program at the Georgetown Preparation Plant. Table 9 presents a comparison between the A-weighted sound levels at the previously identified measurement positions before and after the installation of the noise control treatments. Several comments should preface this table. First, in some cases (such as the primary screens), the treatment has been removed or worn out after the final measurements. Second, in certain curtain installations, some additional noise reduction is anticipated with the addition of ceiling baffles. Finally, some of the noise reductions are estimated, on the basis of either measured levels close to the noise source or measurements on other similar installations in the plant. Since the measurement positions are typically operator or aisle positions, some of them are affected by the noise of several pieces of equipment. In those cases, large noise reductions on a piece of equipment may be obscured by a more modest noise reduction on an adjacent piece of equipment (e.g., the effect of the McNally jigs on the apparent noise reduction of the middling vibrators). This results in Table 9 being more indicative of the noise reduction realized by the worker's exposures.

Table 10 is a comparison of the worker's noise exposures before (from Table 3) and after the installation of the noise control treatments. Although the use of both dosimeter sampling and calculated values makes the comparison difficult in certain instances, the program has clearly resulted in a marked reduction of the noise exposure of these Georgetown Plant employees.

In terms of the effect of this noise control program at the plant operation, blinding of resilient screen decks represents

TABLE 9. SUMMARY OF SOUND LEVELS MEASURED BEFORE AND AFTER TREATMENT.

Measurement Position	Associated Equipment	Measured Sound Levels, dB(A)		
		Before Treatment	After Treatment	Noise Reduction
A ₁	Belt Drives	92	90 - 92 ¹	0 - 2
A ₂	Primary Shaker	94	91 ¹	3
A ₃	Picking Table	94	90 - 92	2 - 4
A ₄	Boney Coal Crusher	93	91	2
B ₁	McLanahan Rock Crusher	93 - 100	91 - 92	2 - 8
B ₂		92	93	+1 ²
C ₁		92	95	+3 ²
D ₁	Secondary Sizing Screens	96	--	1 - 2 ³
D ₂		95 - 97	--	1 - 2 ³
D ₃		97	93	4 ⁴
E ₁	McNally-Baum Jigs	95	92 - 93	2 - 3
E ₂		97	91 - 93	4 - 6
E ₃		94 - 95	91	3 - 4
F ₁	Middling Vibrators	96	92	4
F ₂		95	93 - 94	1 - 2
F ₃		94 - 97	92	2 - 5
G ₁	Clean-Coal Desanding Shakers	96 - 97	93	3 - 4 ⁴
G ₂		96	95	1
H ₁	Ripl-Flo Screen Feed Conveyor	95	92 - 93	2 - 3
H ₂		94	91	3
H ₃	Dryer Feed Conveyor	90	--	--
I ₁	Grundlach Crushers	96	90	6
I ₂		--	--	--
J ₁	Ripl-Flo Screens	101	--	6 - 7 ⁵
J ₂		100	--	6 - 7 ⁵
K ₁	Vacuum Pump	95	--	--
L ₁	Refuse Desanding Shaker	97	95	2
M ₁	Reineveld Dryers	97 - 101	89 - 90	8 - 11
M ₂		99 - 103	91 - 92	8 - 11
N ₁	Jig Blowers	99	92 - 93	6 - 7
P ₁	Wemco Dryers	95	--	--
P ₂		96	--	--
P ₃		96	90	6
Q ₁	Head End Crushed Coal Belt	100	91 - 94	6 - 9
Q ₂	Classifying Shakers	102	96 - 97	5 - 6
Q ₃		104	--	--
Q ₄		103 - 104	--	--
R ₁	Jig Feeder	96	96	0 ⁶
S ₁	Rail Car Unloader (Shakeout)	111 - 113	--	-- ⁷
T ₁	Syntron Feeders	--	--	--

¹Resilient screen decks since removed.

²Apparent change in crusher action.

³Estimated, see text, pg. 3-34.

⁴Additional curtain baffles at ceiling planned, 3 dB more deduction possible.

⁵Estimated based on close-in measurements, screens since removed.

⁶No specific treatments in this area.

⁷Previous measurements indicate sound levels within operator booth were less than 90 dB(A); some deterioration in booth noticeable.

TABLE 10. SUMMARY OF WORKER EXPOSURE DURING FULL-CAPACITY OPERATION.

Job Title	Mobile (M), Stationary (S)	Exposure Coefficient	
		Before Treatment	After Treatment
Wash Box Operator	S	1.4 ¹	1.0 ¹
Picker	S	1.6 - 1.8 ²	0.9 - 1.1 ¹
Loadout Operator	S	0.0 ¹	0.0 ¹
Deister Operator	S	1.5 ²	0.8 - 1.2 ²
Clean-Up (2)	M	2.2 - 2.3 ¹	0.9 ²
Oiler	M	1.3 ¹	-
Mechanic (4)	M	[1.0]*	0.5 ²
Foreman	S	[0.5]	-
Warehouse Tender	S	0.0 ¹	-
Master Mechanic	S	[0.5]	-

¹Based on typical sound levels and work routines.

²Based on dosimeter measurements.

*Brackets indicate estimate based on partial observation.

the major operational problem. In the only two instances where resilient impact pads have caused problems, they were installed in too shallow a chute. Such installations can be prevented either by careful planning or by prior experimentation. Finally, some additional effort is required to monitor visually those pieces of equipment enclosed by curtains, but not to the extent that it hampers the overall operation of the plant.

While noise reduction in coal preparation plants is difficult to achieve and maintain, significant, measurable amounts of noise reduction have been obtained at the Georgetown Preparation Plant without major adverse effects on productivity.

4.2 Recommendations for Application to Other Plants

Many of the materials installed at the Georgetown Preparation Plant under this program proved to be practical noise abatement measures and are generally applicable to other coal preparation plants. The commercially available impact pads and curtains used in this project can provide significant noise reduction with little operational interference. Plant personnel, working with the information given in Appendix C of this report and the technical assistance available from most manufacturers, should be able to install these materials and achieve noise reductions comparable to those achieved at the Georgetown Plant, with a minimum of installation or operational problems.

As demonstrated in this project, open-top chutes in worker-accessible areas should be covered with sheet steel (or equivalent) wherever possible. In addition, chutes carrying small material (typically <2 in.) can be treated with resilient linings, whereas chutes carrying larger material (2 to 7 in.) may be more practically treated with ceramic linings and/or exterior lagging or damping.

The experience with resilient screen decks at Georgetown prevents their being recommended for general use at this time. However, improved products should be forthcoming with (1) better bonding, (2) more durable materials, and - as a result of the first two - (3) minimized blinding. This last improvement will be particularly important to operations that utilize slow-speed crank-arm shakers with limited throw.

It is also recommended that operators who are about to undertake extensive noise control programs assign a single crew to the installation of noise control treatments. The results at the Georgetown Plant confirm that an experienced crew will

produce higher quality installations, while reducing the required installation time. One final point: *Once a treatment has been installed, it must be monitored periodically and repaired when necessary to ensure that the initial noise reduction achieved will be maintained over the life of the treatment.*

4.3 Future Research

It should be clear, from the results of this study, that while resilient screen decks do provide substantial noise reductions, their problems in coal handling prevent them from being a widely acceptable solution at this time. To overcome these problems, the basic parameters influencing blinding and delamination (in composite decks) need to be quantified. Because the parameters are likely to be different for coal than for other materials, such as gravel, it is recommended that such a study be restricted to coal handling only. As these data become the basis for new product development, it would be beneficial to measure the performance differences of various screens under controlled conditions to provide plant operators with the accurate comparative data that will aid them in selecting screens best suited to their needs.

REFERENCES

1. E.E. Ungar, G.E. Fax, W.N. Patterson, and H.L. Fox, "Coal Cleaning Plant Noise and Its Control," BBN Report No. 2827 (1974).
2. "Department of the Interior Noise Standard Issued Under the Federal Coal Mine Health and Safety Act," Title 30, Chapter I, Parts 70 and 71, pertaining to noise.
3. E.E. Ungar, C.L. Dym, and M.N. Rubin, "Practical Reduction of Noise from Chutes and Screens in Coal Cleaning Plants," BBN Report No. 3337 (June 1976).

APPENDIX A
FLOOR PLANS FOR GEORGETOWN PREPARATION PLANT

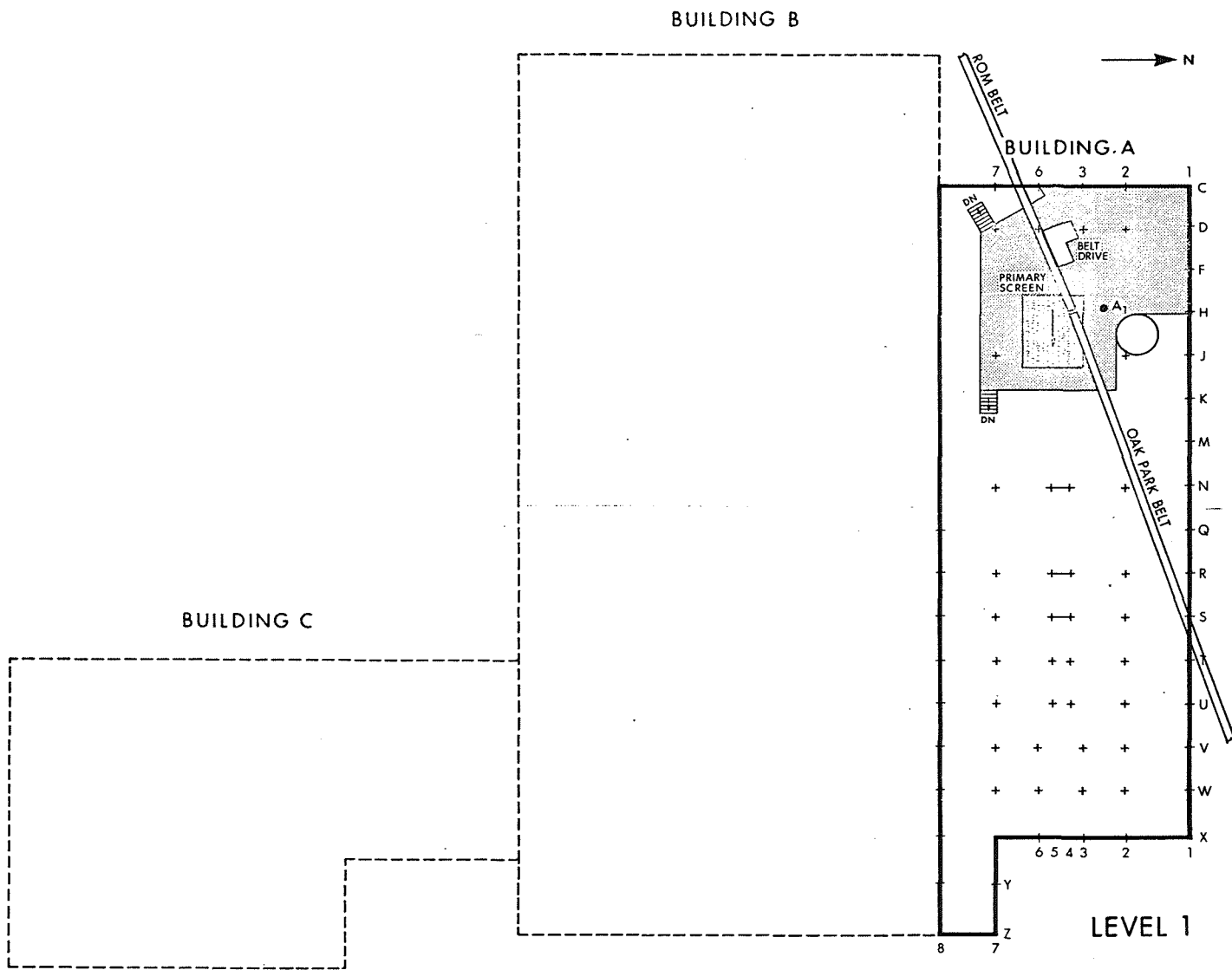


FIG. 3. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 1.

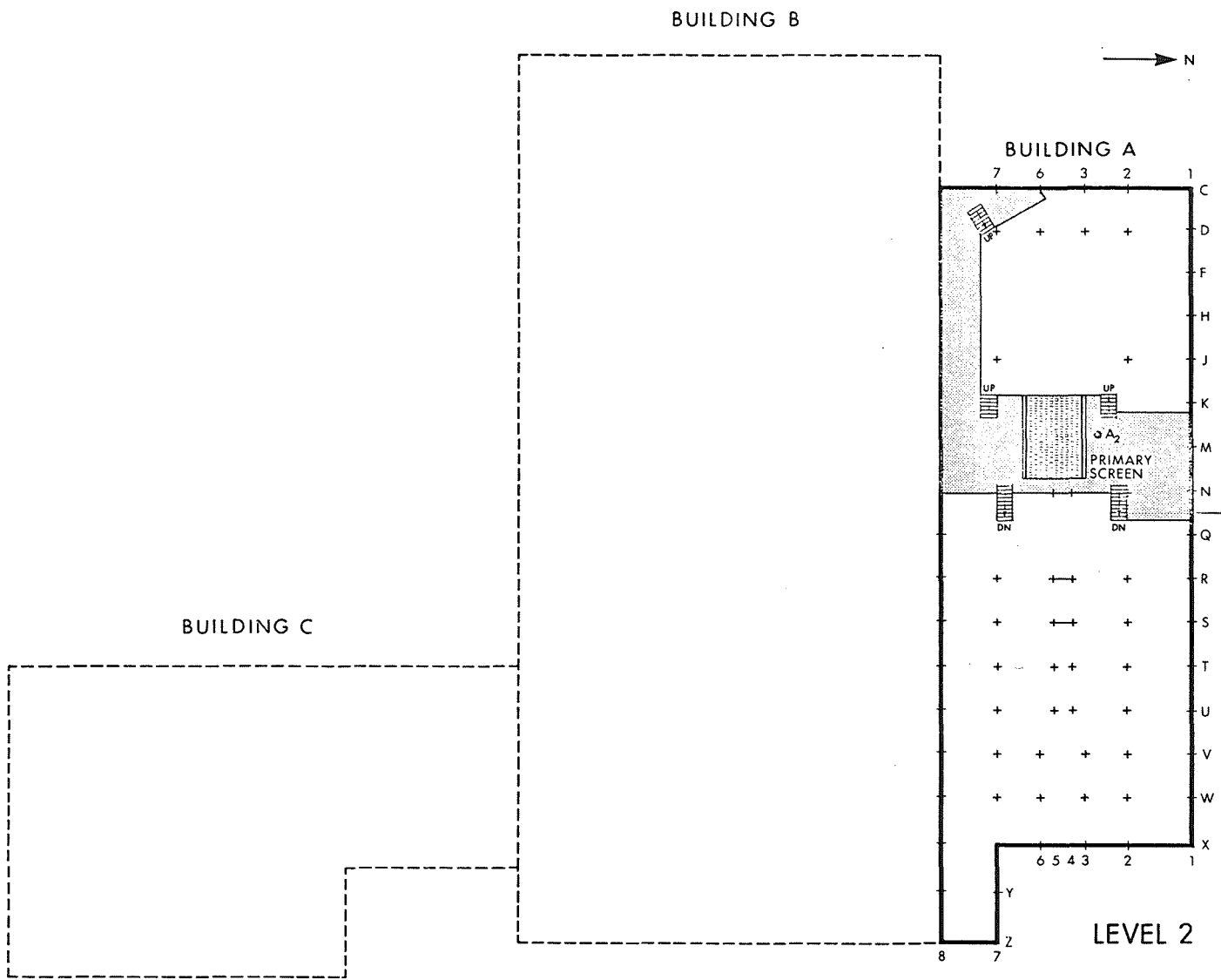


FIG. 4. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 2.

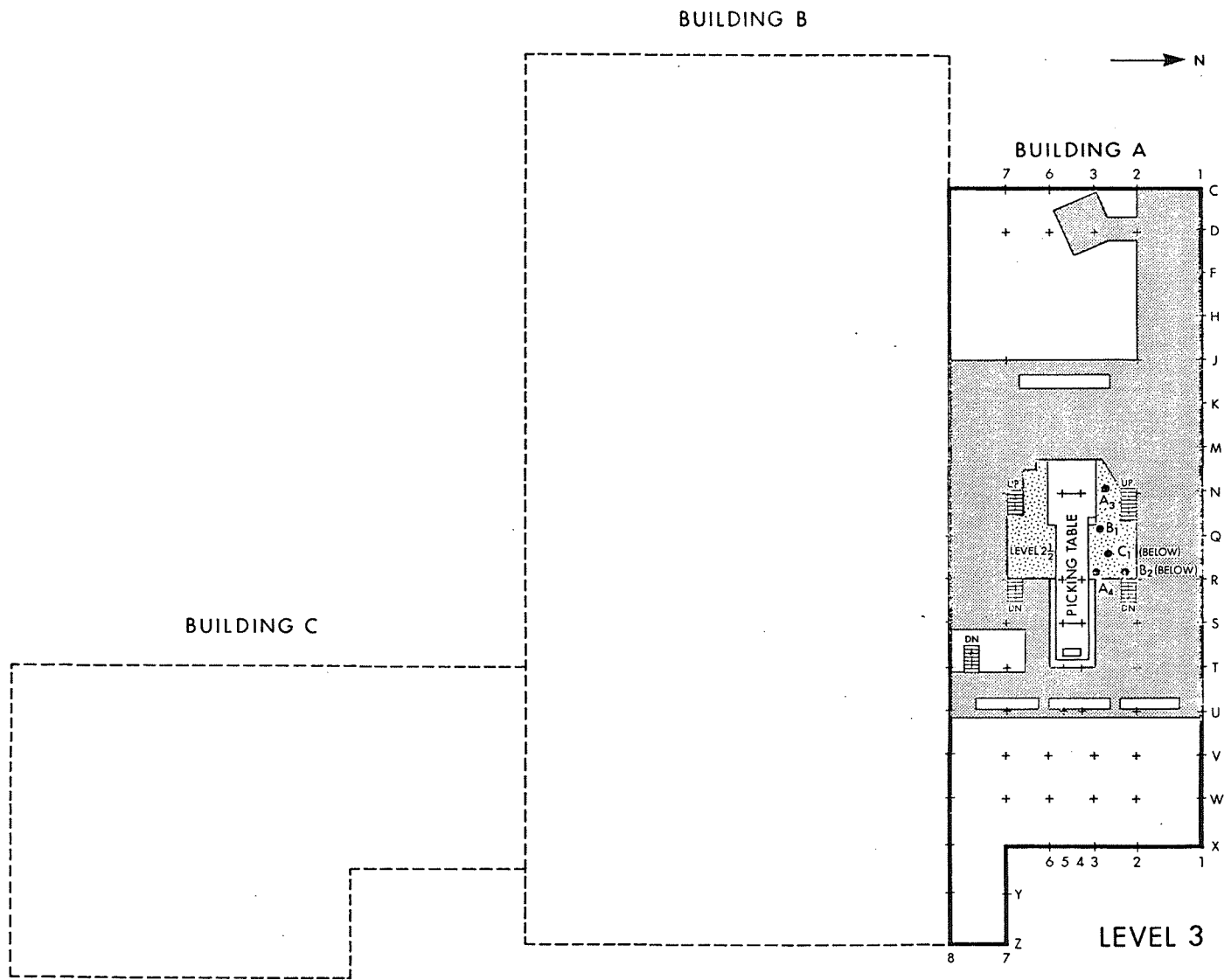
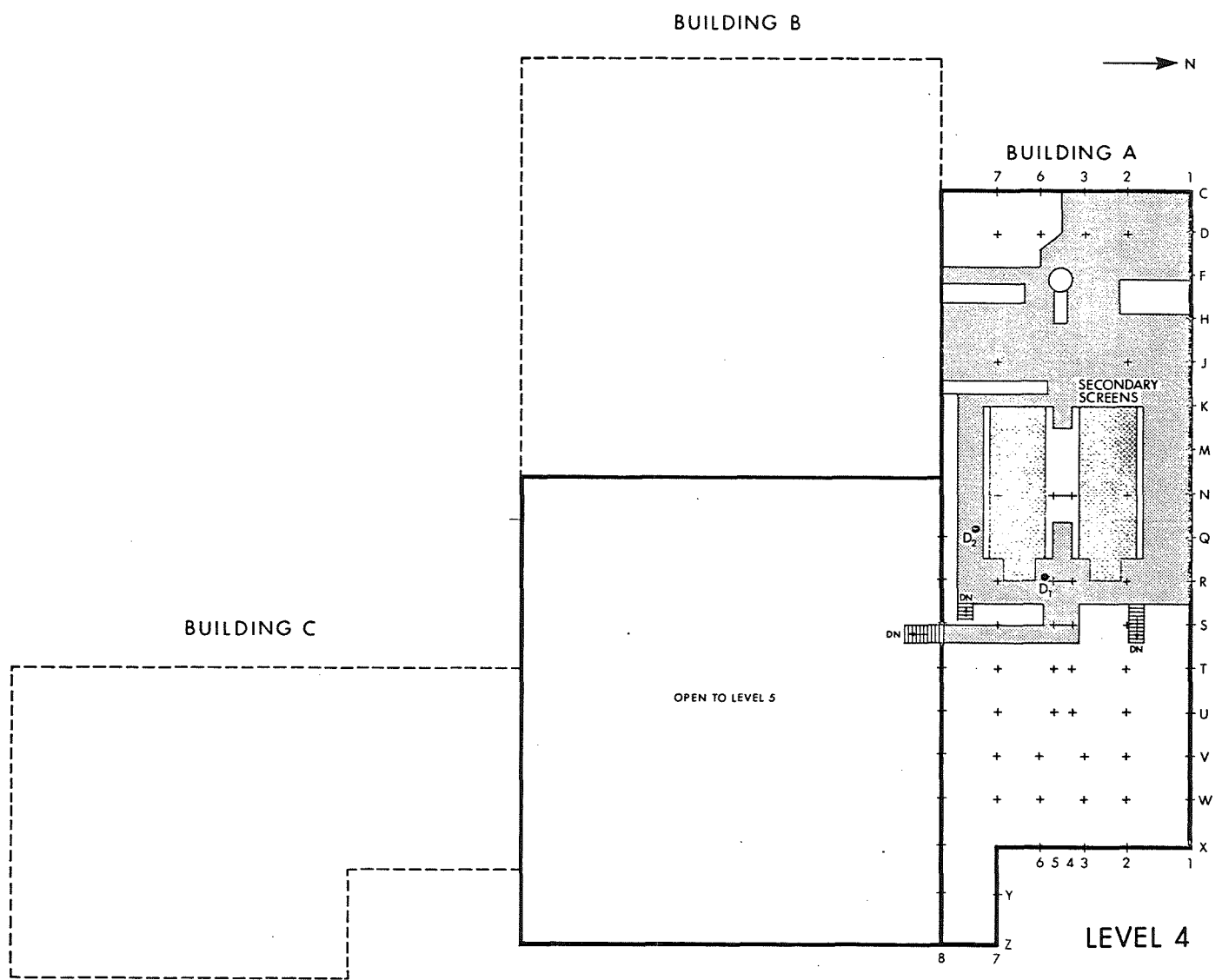


FIG. 5. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 3.



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FIG. 6. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 4.

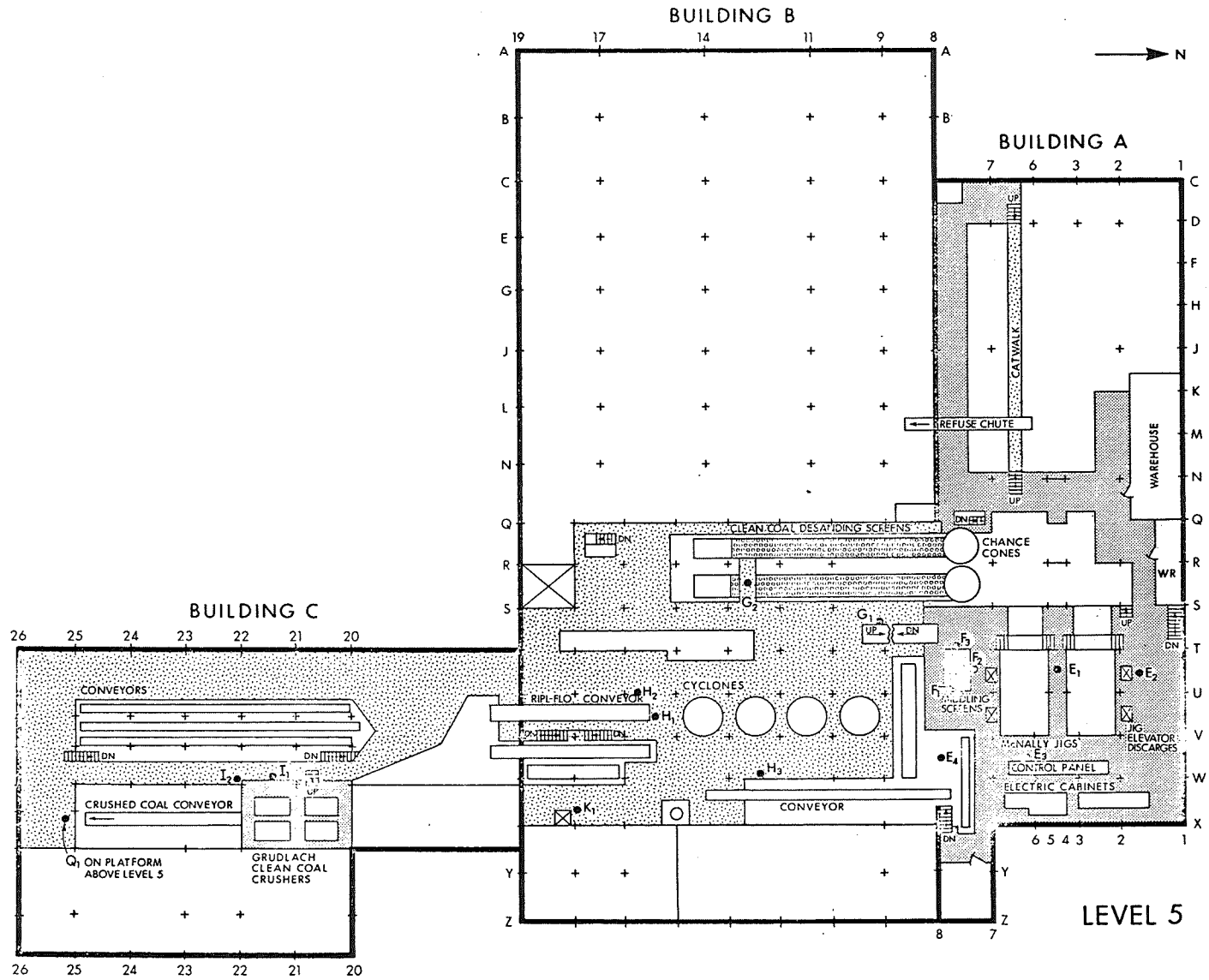


FIG. 7. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 5.

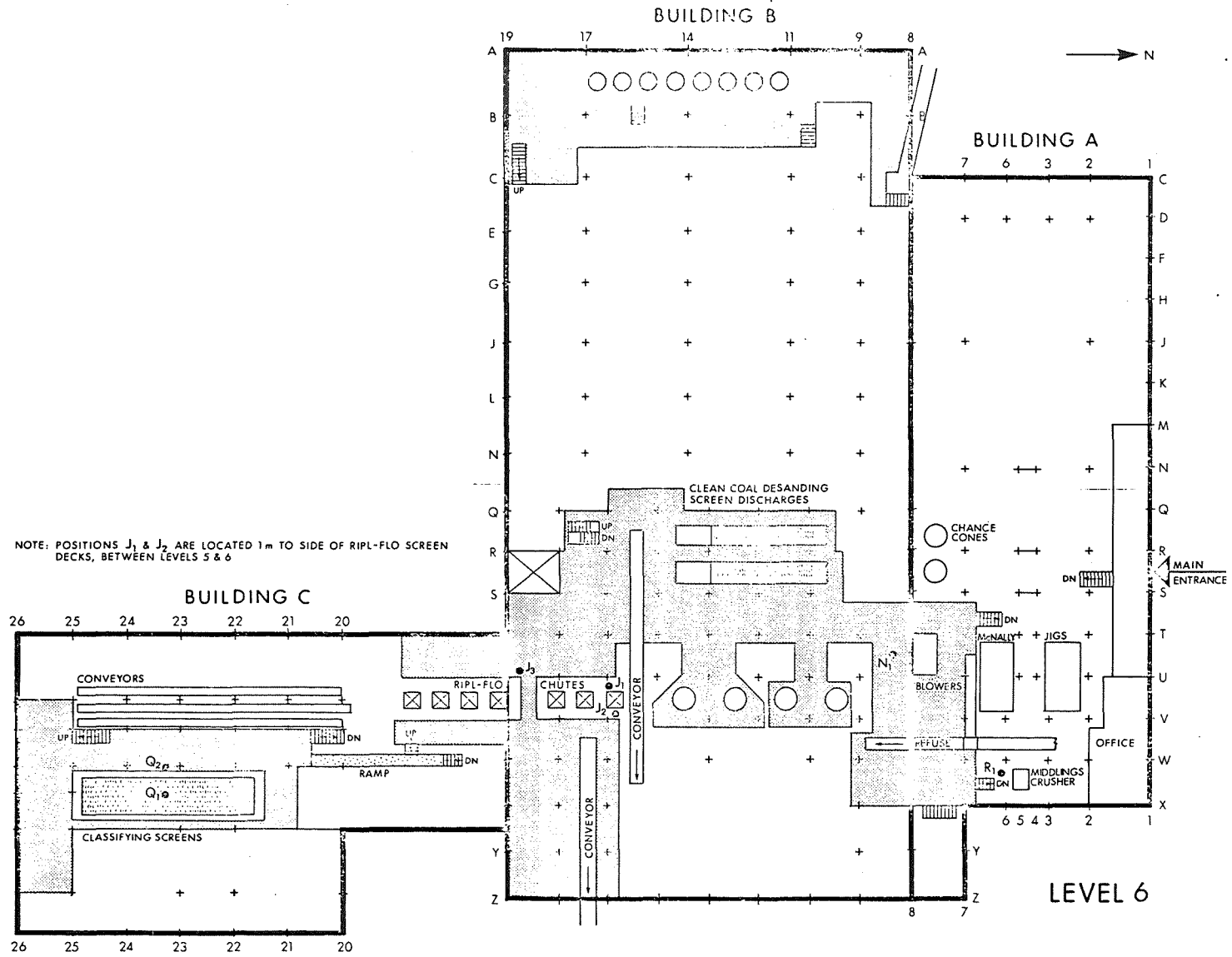


FIG. 8. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 6.

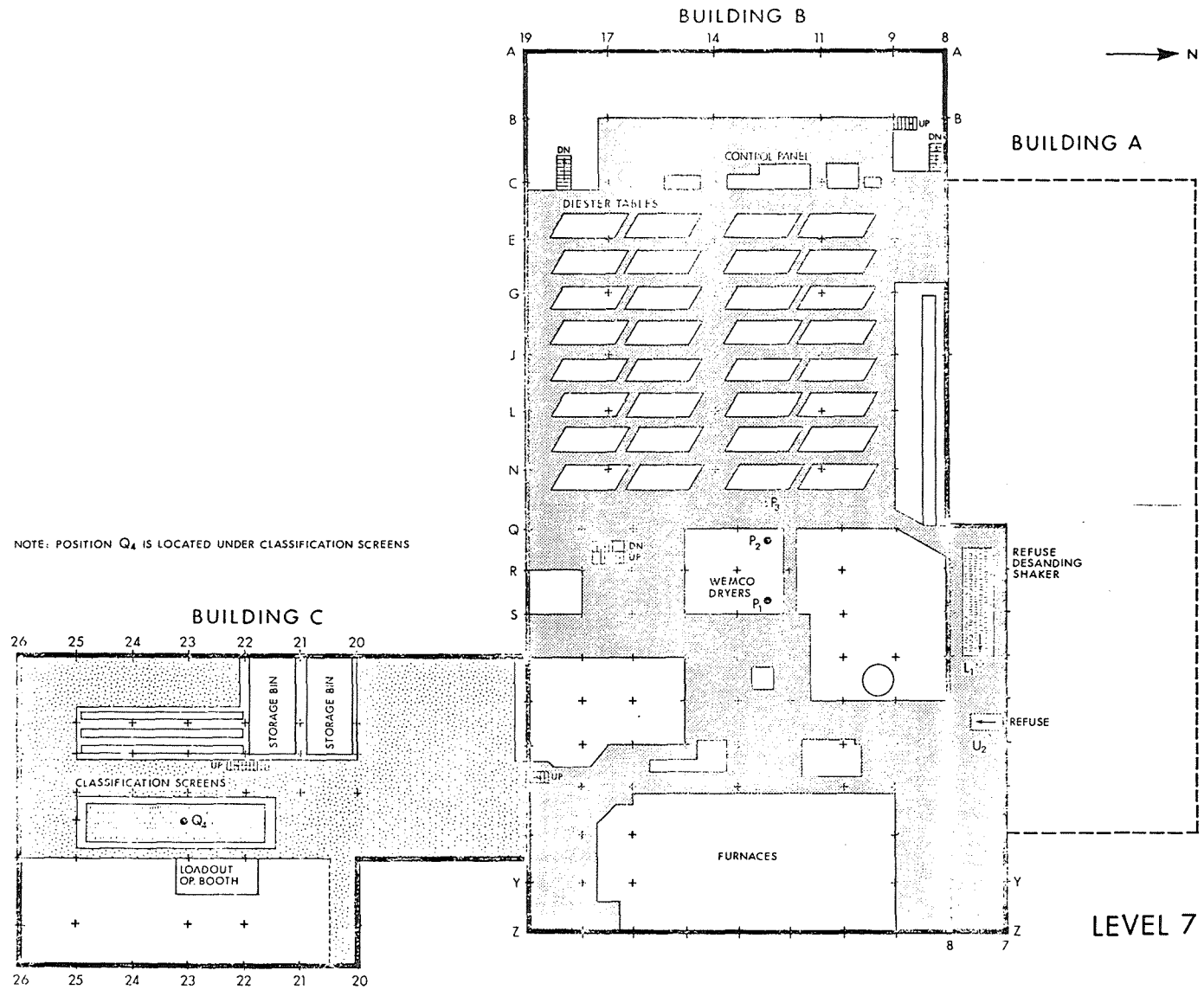


FIG. 9. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 7.

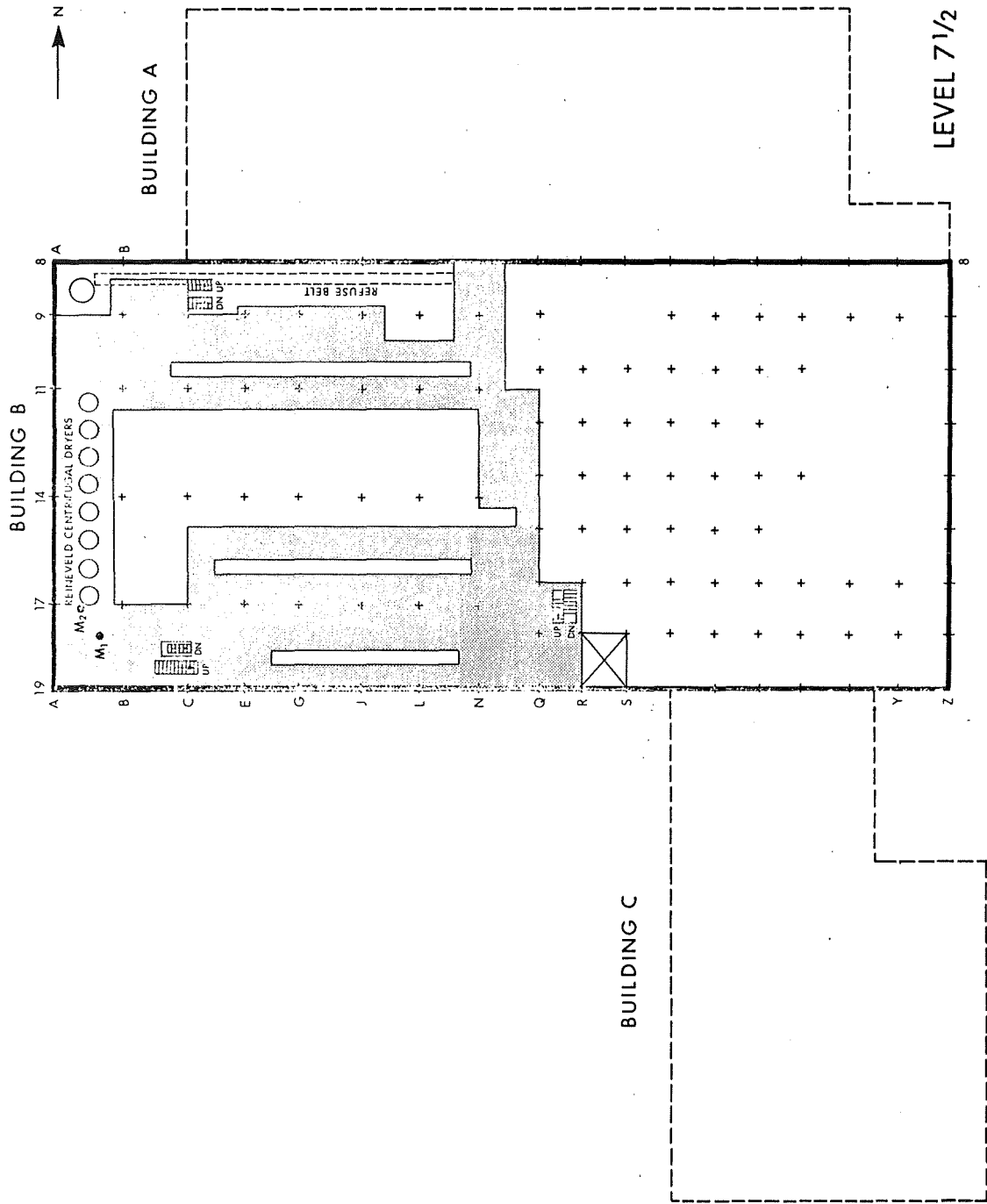


FIG. 10. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 7 1/2.

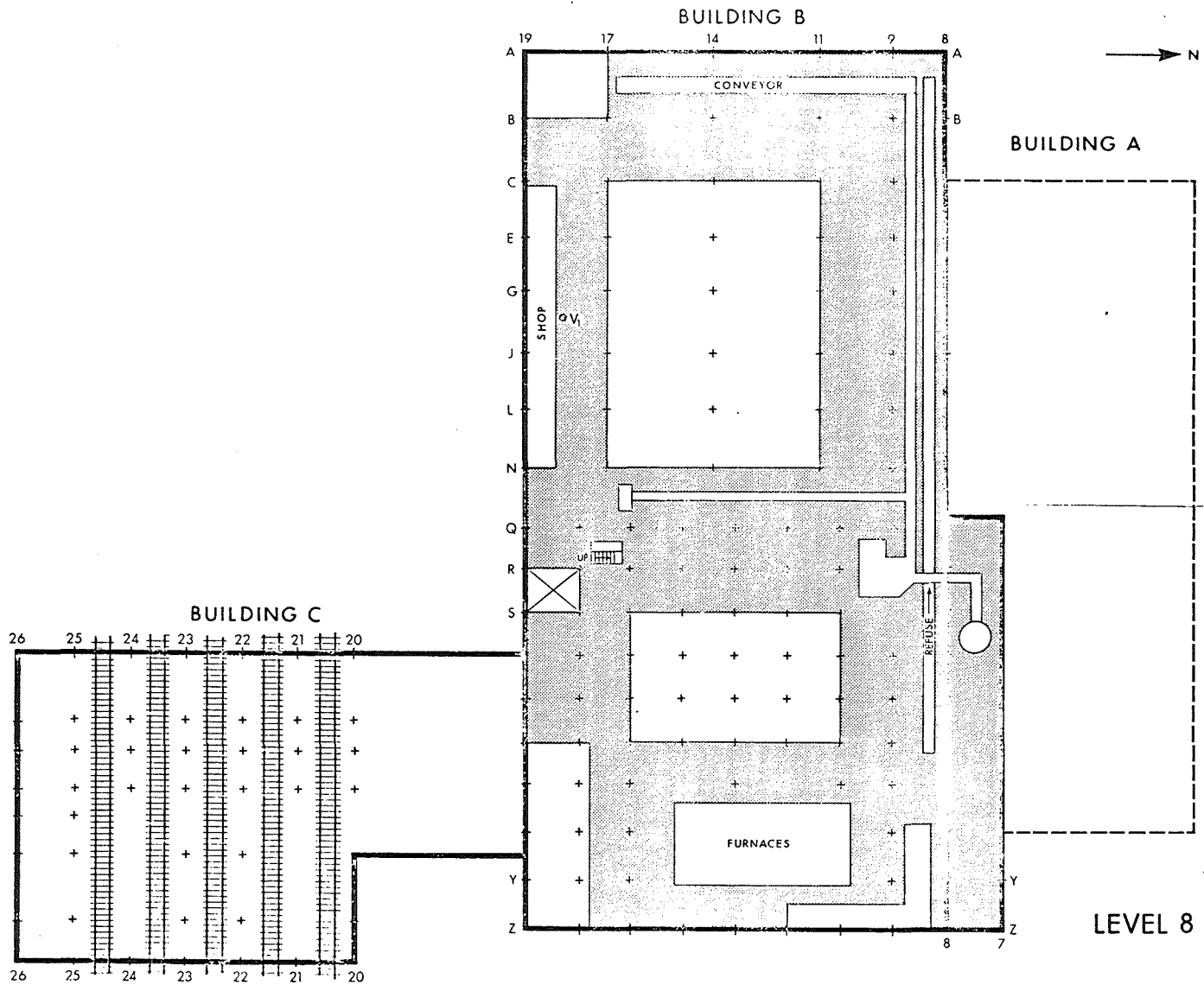


FIG. 11. GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 8.

APPENDIX B: DETAILED SOUND SURVEY

The results of the sound level survey are summarized in this appendix. Each building level is described (from top to bottom) in terms of the equipment located in the area, the noise sources and sound levels, and worker exposure. The major equipment and measurement locations are identified in the floor plans in Appendix A.

Level 1

Level 1 is the uppermost level of the plant, where the conveyor belts carry raw coal into the plant. There are two conveyor belts: the Oak Park belt, which brings in coal from the Oak Park underground mine, and the run-of-the-mine (ROM) belt, which carries the surface-mined coal from the storage bins. The principal noise sources are the drive units for these two belts, as well as the leading section of the primary sizing screen. The A-weighted sound level at Position A₁, on Level 1, was 92 dB(A) when the plant was operating normally.

Preliminary measurements indicated that the ROM belt drive was 3 to 4 dB quieter than the Oak Park belt drive. Figure 12 shows the 1/3-octave band sound spectra measured 3 ft from the Oak Park belt drive with the plant at full capacity and with the belt drive operating alone. Even though the gear tone at 630 Hz was quite audible, the overall noise generated by the coal flow over the primary screens is approximately equivalent to the drive unit noise [94 dB(A)]. At the nearest worker position, A₃ (the picking table operator), the primary screen noise becomes more significant than the drive unit noise.

Because workers are not normally stationed in this area, it was classified as a limited-exposure (Type III) area. Since the

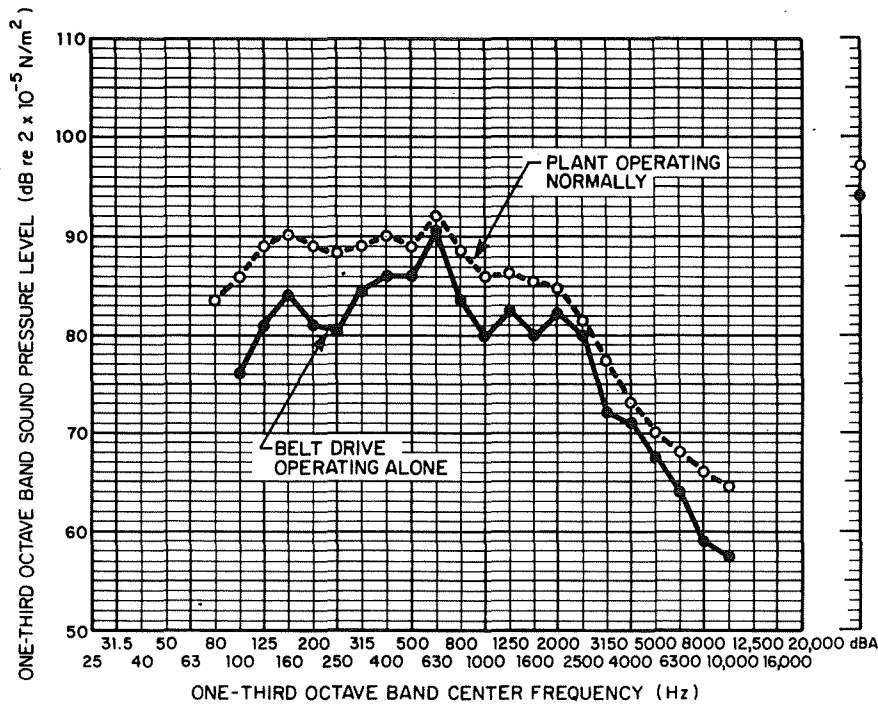


FIG. 12. OAK PARK BELT DRIVE UNIT NOISE.

drive unit noise was not a principal contributor at the picker position, it was not selected for treatment under this program.

Level 2

Level 2 contains the main section of the primary sizing screen. The sound level at Position A₂, alongside the screen, was 94 dB(A) during normal operation. The sound level with the primary screen running alone (without coal) was 90 dB(A); it represents the lowest noise level achievable with the installation of "quiet" screen decks. Figure 13 shows the 1/3-octave band sound spectra measured with the plant operating normally and with the shaker running alone without coal. It can be seen

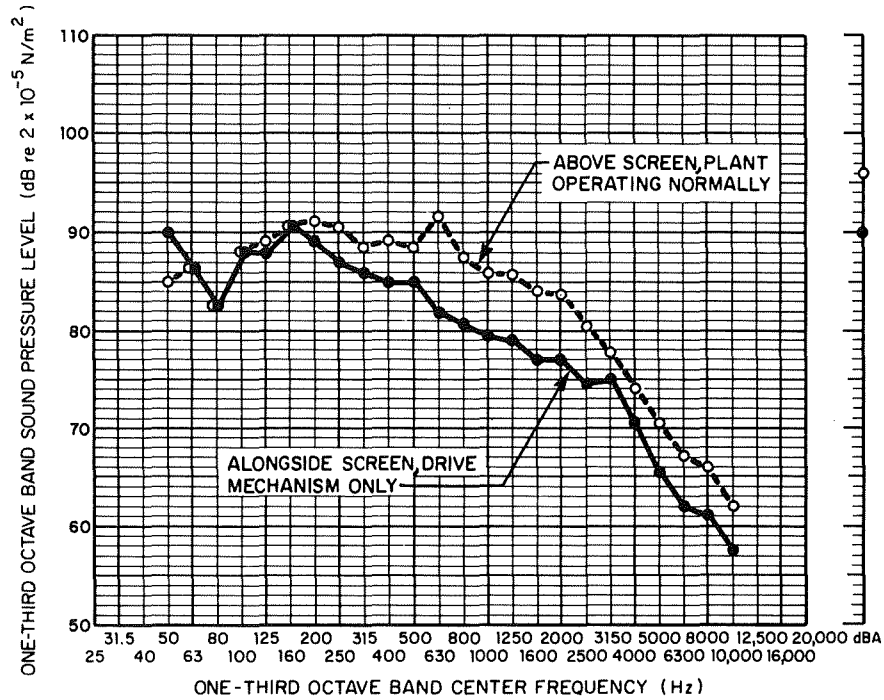


FIG. 13. PRIMARY SCREEN AND DRIVE MECHANISM NOISE.

that the noise of the coal flow is significant between approximately 250 and 2500 Hz. Outside of this range, the drive mechanism becomes comparable to the screen noise.

While Level 2 contains no workers, the effect of the screen noise on the picking table operator led to its classification as a Type II (frequent-exposure) area.

Level 3 (Also 2½)

The picking table is located on Level 2½ at the discharge of the primary shaker. The picking table operator, who is located at Postion A₃ for the entire shift, was typically exposed to sound levels of 94 dB(A). Peaks to 100 dB(A) were occasionally

measured at this location as particularly large rocks impacted the steel infeed chute to the McLanahan crusher. The baseline noise exposure coefficient for this worker was 1.7 to 1.8.

The infeed to the McLanahan rock crusher is located just after the picker. The sound level measured 6 ft above the crusher rolls was 78 dB(A) when the unit was not crushing; it peaked to 100 dB(A) when rocks were falling into the crusher and impacting the chute walls. The infeed to the Boney coal crusher, which crushes the plus-7-in. coal, is also located at the end of the picking table. With the crusher running alone (without coal), the sound level was 77 dB(A) 2 ft above the crusher roll. Even while coal was crushed, the sound level from this crusher was normally below the general sound level at the picker position with the plant operating normally.

With the equipment in this area operating without coal flow, the sound level at Position A₃ was 88 to 90 dB(A). Because the sound levels measured at the crusher rolls were low, this ambient level reflects the contribution of the picking table and primary screen drive mechanisms and the vibration of the picking table itself. The major noise sources in this area during normal operation were the impact of the large chunks of coal and rock on the primary screen, picking table, and crusher infeed chutes.

The presence of the picking table operator at Position A₃ makes this a continuous-exposure (Type I) area.

Level 4

Level 4 is an intermediate level that contains the center sections of the two secondary sizing screens, including the crank-arm drive mechanisms. The A-weighted sound levels measured alongside these screens were originally 95 to 97 dB(A).

With the screens running without coal, the sound levels in this area were 77 to 78 dB(A), while operating alone, and 87 to 88 dB(A), with the equipment on Levels 3 and 5 operating. When the crank mechanisms operated without coal, the low levels of sound were typical of properly operating low-speed crank-arm shakers. Those levels are clearly overshadowed by the contribution of equipment located above and below these screens, primarily the McNally jigs on Level 5. As a result, no noise control is needed for the screen drive mechanism. The high sound levels caused by coal impacts, on the other hand, made these screens prime candidates for resilient or other quiet screen decks.

Since plant employees pass by these screens to reach the upper levels of Building A, and since the screen noise (during full operation) was audible at the entrance to the warehouse and washroom, these screens were considered to be in a Type II (frequent-exposure) area.

Level 5

In the floor plans, Level 5 is a combination of Level 5 in Building A and Level 5½ (one-half level down) in Buildings B and C. This level contains a large amount of equipment, including the separation equipment for two of the three cleaning circuits, the warehouse, and the washroom. As such, it may be considered the main level of the plant.

In Building A, the sound level at the entrance to the washroom and warehouse was originally 93 to 94 dB(A), primarily because of the noise of the secondary shakers (located just above this area) and the McNally coal jigs.

The sound levels around the McNally jigs ranged from 94 dB(A) at the control panel to 97 dB(A) between the jigs and behind the

No. 2 refuse chute. At the middling vibrator, the sound was between 94 and 100 dB(A).

The McNally jigs and the middling vibrators were the major noise sources in this area. However, additional sources, including the chance cones, clean-coal desanding screens, secondary screens, crop belt discharge, and the bar screen (which dewater the clean coal from the jigs) also contributed to the levels in this area.

Figure 14 shows the A-weighted 1/3-octave band sound spectra measured at Position E₂, 6 ft behind the No. 2 jig refuse chute. The two conditions represented are the original sound levels with the plant operating normally [97 dB(A)] and the jig elevator operating alone without refuse [88 dB(A)]. The latter spectrum

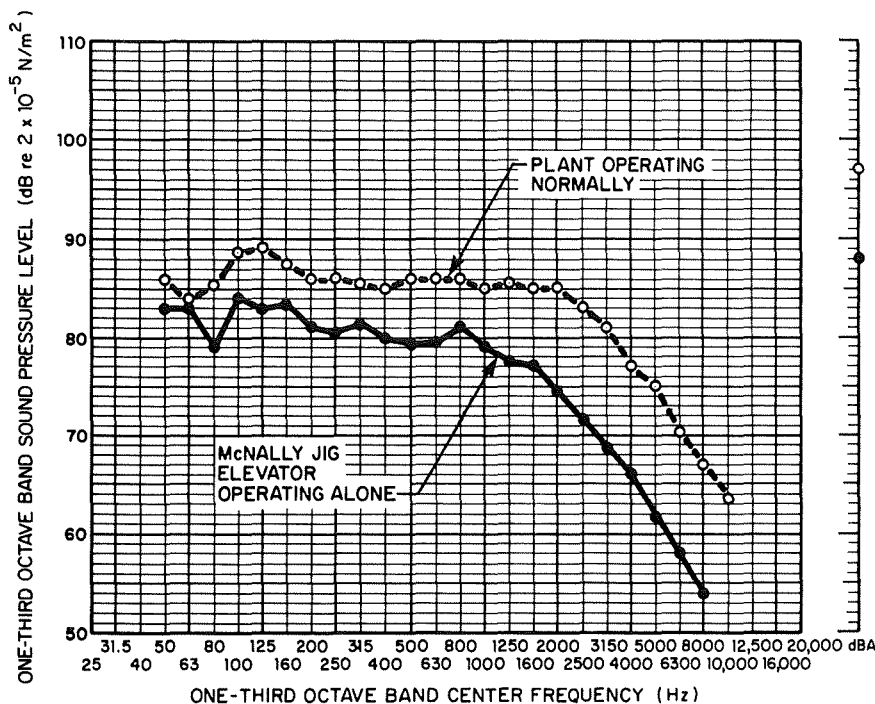


FIG. 14. McNALLY JIG REFUSE ELEVATOR NOISE.

represents the noise of the refuse baskets impacting and rubbing on the elevator structure, a level which varies with chain tension and wear. Without major modifications of the elevator structure, this latter condition represents the lowest sound level achievable through treatment of the chutes and other sources. The 97-dB(A) total sound level at this position was primarily caused by the refuse impacting the chute walls as it is dumped by the elevator baskets after reaching the top of their travel. Measurements taken at the control panel operator position (Position E₃) indicate that the noise from the air pulsation in the water bath amounts to 85 to 87 dB(A). The contribution of the elevator basket operation at this position was approximately 86 dB(A). These data indicated that 88 to 90 dB(A) was the minimum sound level that could be obtained at the control panel without major design modification of the equipment, and as a result, the cleaning process.

The A-weighted sound level measured 3 ft from the discharge of the No. 2 middling vibrator was 100 dB(A). The spectrum is basically broadband, with a slight peak (4 dB) in the 500-Hz 1/3-octave band.

Measurements taken with the plant operating at full capacity indicate that the "crop belt," located between Buildings A and B, contributes about 84 to 87 dB(A) at the control panel (Position E₃). The washbox (McNally jig) operator is stationed in this area for his entire shift, and other plant workers frequently pass through this area during the day. Therefore, the washbox area is classified as Type I (continuous-exposure).

The major equipment located in Building B (one-half level down) included the clean-coal desanding screens, fine coal drying cyclones, and the Rip1-Flo (screen) feed conveyor. The A-weighted

sound level measured alongside the clean-coal desanding screen (Position G₁) was 96 to 97 dB(A) during full operation.

Figure 15 shows the 1/3-octave band spectrum measured at another position alongside the clean-coal desanding screens. Despite a peak in the 125-Hz 1/3-octave band, the A-weighted overall level [99 dB(A)] is controlled by the high frequencies. The noise caused by coal-related impacts is 97 to 98 dB(A), while the water spray noise amounts to 91 to 92 dB(A). The noise of the clean-coal desanding shakers dominates the north end of Building B.

The Ripl-Flo feed conveyor, which spans the line between Buildings B and C, was the other major noise source in this area.

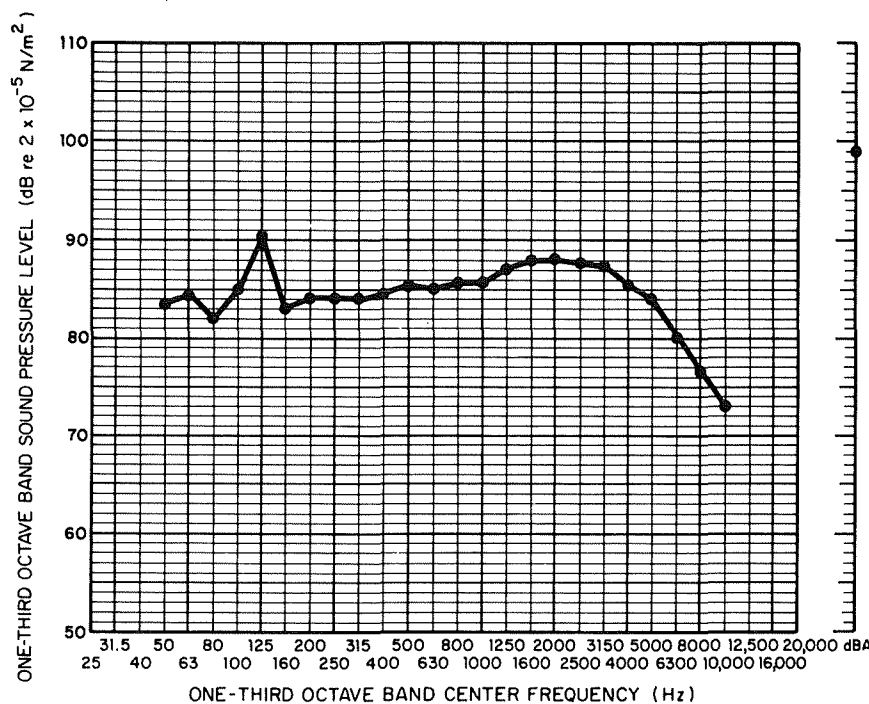


FIG. 15. SOUND POWER LEVELS MEASURED ALONGSIDE CLEAN-COAL DESANDING SHAKERS.

Figure 16 shows the spectrum measured 3 ft from the conveyor. The scraping of the steel flights against the conveyor bottom creates a screeching noise (not the 8000-Hz spike in the sound spectrum), which can generate up to 100 dB(A) at this position.

A Hoffman Model 4206 centrifugal exhaust vacuum pump was located behind the Rip1-Flo conveyor. The A-weighted sound level measured 5 ft from the unit (Position K₁) was 98 dB(A); tones at 63 Hz and 125 Hz were prominent.

The area around the vacuum pump was not usually accessed by plant workers and was therefore classified as Type III (limited-exposure); however, the remainder of Building B, Level 5, was classified as a Type II (frequent-exposure) area.

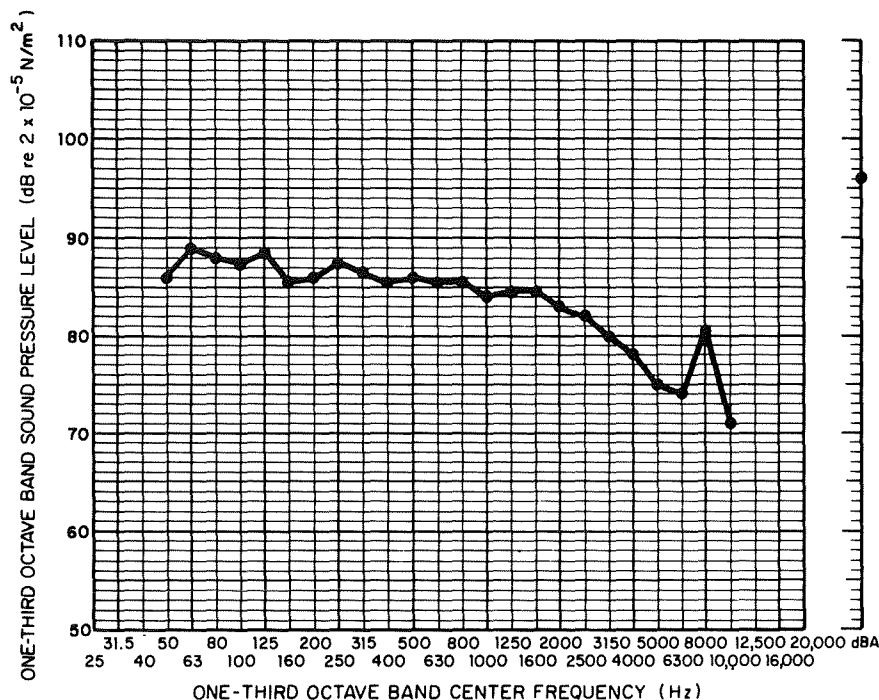


FIG. 16. RIPL-FLO SCREEN FEED CONVEYOR NOISE.

The equipment in Building C is primarily associated with final crushing, sizing, and rail loading. Level 5 in this building contains the four Grundlach (clean-coal) crushers, the head end of the 7 × 1¼-in. clean-coal belt, three conveyor belts from the storage bins below, and the crushed coal conveyor that carries the clean coal from the crushers to a dump point above the head end of the classifying screens.

The sound level at Position I₁ was 96 dB(A). The noise of the crushers, when running, was the major noise source in this area. This includes the noise of the coal impacting the infeed chute as it comes off the clean-coal belt and the noise of the discharge chutes. The sound level of the crushers without coal was 86 dB(A), indicating that the gearing, etc., was not a problem.

The discharge of the crushed coal belt (from the crushers) was also a major noise source on this level. The sound level measured at the head end of the belt, where the coal coming off the belt impacts the chute walls, was 100 dB(A).

The noise radiating from the classifying screens, one level down, also contributed to the sound levels in this area.

Because clean-up men worked in this area for portions of their shift, it was classified as a Type II (frequent-exposure) area.

Level 6

As in the case of Level 5, all three buildings are included on Level 6. In Building A, Level 6 is the ground floor. The equipment on this level includes the bottom of the Chance Sand Flotation Cones and McNally coal jigs, blowers for the jigs, and a crusher for the middlings coming from the jigs. The discharge of the refuse chutes from the jig elevators is also located on this level.

The major noise sources in Building A on this level were the Ingersoll-Rand fans used to supply air for the McNally jigs and the refuse discharge chutes. The sound level 10 ft from the No. 1 fan (Position N₁) was 99 to 102 dB(A), while the sound level adjacent to the discharge chute (Position R₁) was 96 dB(A). In addition, there was some rumbling from the jig walls as refuse dropped down to the bottom and was dredged up by the elevator baskets. Although the middling crusher had the potential for being another major noise source, it was not used enough of the time to be considered. The presence of the sampler in this area during a portion of his shift makes this a Type II (frequent-exposure) area.

Building B (Level 6) contains the discharge end of the clean-coal desanding shakers, the bottom of the fine coal cyclone dryers, the Rip1-Flo discharge chutes (which actually span Buildings B and C), and several conveyors. While no operators are stationed in this area, it is a central location where workers pass in transit from one area of the plant to another.

The major noise sources in Building B on this level were the open discharge chutes on the clean-coal desanding shakers and the Rip1-Flo discharge chutes. In both cases the noise, 95 to 98 dB(A), was primarily high frequency and was caused by coal impacting the chute walls. The difference, however, was that the clean-coal desanding chutes were open, and thus the sound both propagated directly from the impact point and was reradiated by the chute wall. Since workers frequently pass this area, it was classified Type II.

The Rip1-Flo screens themselves are actually on a half level above Level 6 and also represent significant noise sources. Figure 17 shows the sound spectrum measured between the No. 2 and

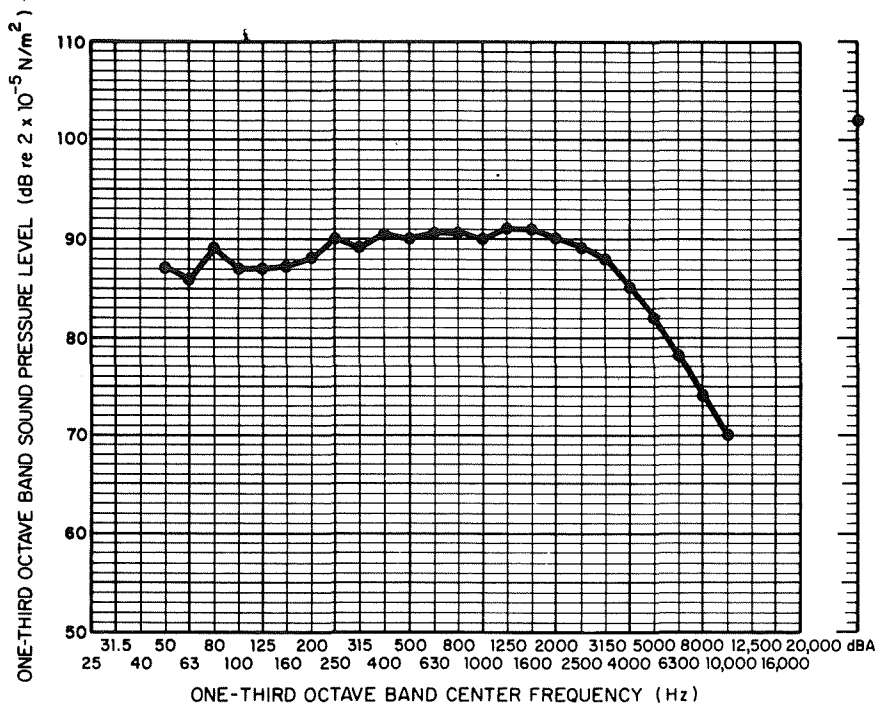


FIG. 17. SOUND POWER LEVELS MEASURED BETWEEN NO. 2 AND NO. 3 RIPL-FLO SCREENS.

3 Ripl-Flo screens on this half level. The spectrum is typical of such high-speed small-material screens, i.e., relatively broadband with substantial energy above 100 Hz. When these screens operated without coal, the overall level around them was approximately 95 dB(A), representing the lowest sound level attainable without modifying the action of the screen. Although this is not a high-access area (4 of the 7 screens are enclosed in a sheet metal room), the effect of the screen noise in adjacent plant areas resulted in its classification as a Type II area.

The classifying screen is located in Building C on Level 6. The original sound level at Position Q₂ was 102 to 103 dB(A)

during full operation. The classifying screen was the dominant noise source in this area. Other related sources were from coal impacting the infeed and discharge chutes.

While no worker is stationed at this screen for his entire shift, workers pass by this unit when walking through the loadout area and clean-up men may spend as much as 1 to 2 hours per day in this area. Therefore, the area was classified as a frequent-exposure, or Type II, area.

Level 7

The equipment on Level 7 is concentrated in Buildings B and C. Building B contains the Deister tables (used to clean the fine coal), the Wemco dryers (which receive coal from the clean-coal desanding shakers), and a refuse desanding shaker (used to reclaim the sand from the refuse leaving the bottom of the chance cones).

The Wemco dryers and the refuse desanding shaker were the two predominant noise sources in Building B on this level. The sound level measured at the Deister table control panel was 88 dB(A) with all equipment operating.

The noise in the Wemco dryer area results from coal impacting the infeed chute walls and dryer components (as well as drive unit noise). At Position P₁, the sound level was 95 dB(A) during normal operation and 92 dB(A) when the dryers were run without coal, indicating that the drive noise would still exceed 90 dB(A), even if all the impacted chute and dryer walls were completely eliminated as noise sources.

The Wemco area was classified as a frequent-exposure area, Type II, because the Deister table operator spends a portion of his shift near the dryers and other plant workers occasionally pass by the units.

The sound level measured at the discharge of the refuse de-sanding shaker (Position L₁), with the plant operating at full capacity, was 97.5 dB(A). With the shaker operating alone without coal, the sound level was 94 dB(A), primarily from water spray and drive noise. There is little worker exposure to this shaker, and the area was therefore classified as Type III (limited-exposure).

As mentioned above, the Deister tables were not a significant noise problem, even though an operator is in the area for the majority of his shift.

Building C contains the clean-coal storage bins and feed conveyors and the lower section of the classifying shaker, including the discharge chutes, and degradation conveyor. The degradation conveyor is a chain conveyor with steel flights that drag along the steel conveyor bottom pan, generating an almost continuous screeching noise. The noise from the classifying screens, discharge chutes, and degradation conveyor generated 103.5 dB(A) at Position Q₄ under the classifying shaker.

As in the case of the classifying shaker (Level 6), no operator is permanently assigned to this area. However, clean-up men may be present in the area for as much as 1 to 2 hours per day. In addition, the loadout operator booth is located adjacent to this area, requiring those workers who enter and leave the booth to pass through this high-noise area. [The sound level inside the booth, however, was below 80 dB(A)]. Therefore, this area (Level 7, Building C) was classified as a Type II (frequent-exposure) area.

Level 7½

Level 7½ is the half level in Building B that contains the Reineveld centrifugal dryers. The 7 Reineveld centrifugal dryers are the only significant noise sources in this area; the remaining portion of the area, which is devoted to storage, is relatively quiet. The sound level measured at the south end of the row of 7 dryers (Position M₂) was 99 to 103 dB(A). Figure 18 shows the 1/3-octave band sound pressure level measured at this position. Note the prominent 1000-Hz peak in the spectrum. Although there was a substantial amount of low-frequency vibration in the building's structural members (10 dB less than the dryers

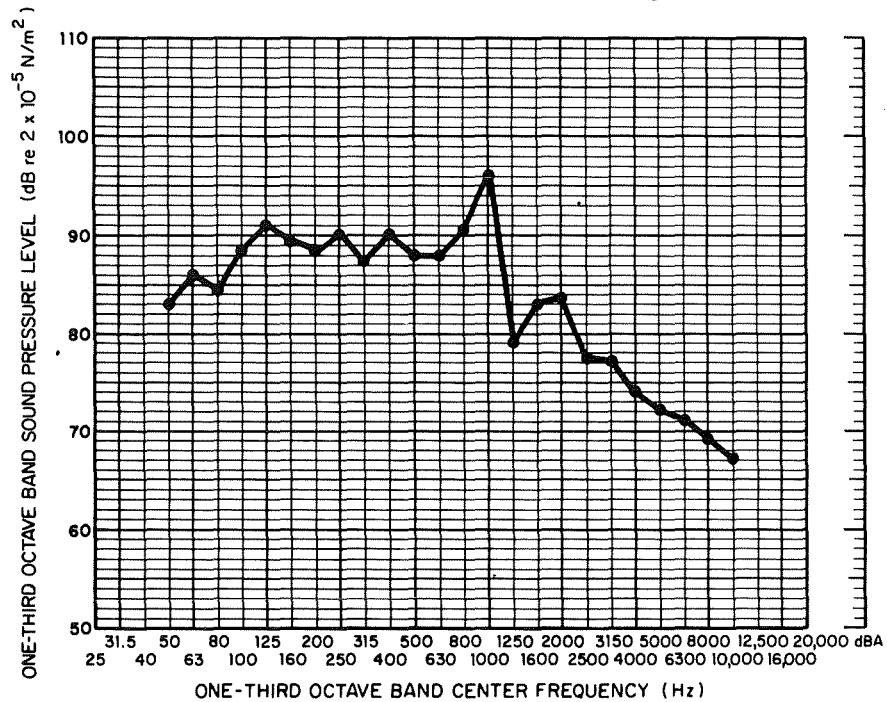


FIG. 18. SOUND PRESSURE LEVELS MEASURED AT POSITION M₂, ALONGSIDE REINEVELD CENTRIFUGAL DRYERS.

themselves), the noise was radiated primarily from the dryer bodies. This area was categorized as Type II (frequent-exposure).

Level 8

Two maintenance shop areas, the refuse belt, and the furnace control panel are located on Level 8 in Building B. Building C contains only rail lines and cars for transporting the clean coal. The sound level at the maintenance desk in the west end of the main shop area (Position V₁) was 90 dB(A), and the sound of the Reineveld centrifugal dryers was quite audible throughout the west end of this shop area. Evidence of the influence of the Reineveld dryers in this area shows up when the sound spectrum measured at Position V₁ in the shop area (Fig. 19) is compared with that measured closed to the dryers (Fig. 18). The shapes of the spectra match quite closely from 160 Hz up to 20,000 Hz, including the 1000-Hz peak. The overall level difference between the two curves in this frequency range is approximately 10 dB. Mechanics, welders, and others may spend extended periods of time in this area depending on their work load, and therefore this area was classified Type II.

At the east end of Building B is the control panel for the furnaces. The sound levels are below 90 dB(A), and since an operator is located here for his full shift, it was classified as a Type I (continuous-exposure) area.

Rail Car Unloading

Two types of rail car unloaders are used to unload the raw coal coming into the plant via rail car: mechanical shakeout and the more modern rotary dump. The sound level during mechanical shakeout can reach 111 to 113 dB(A) at typical operator positions.

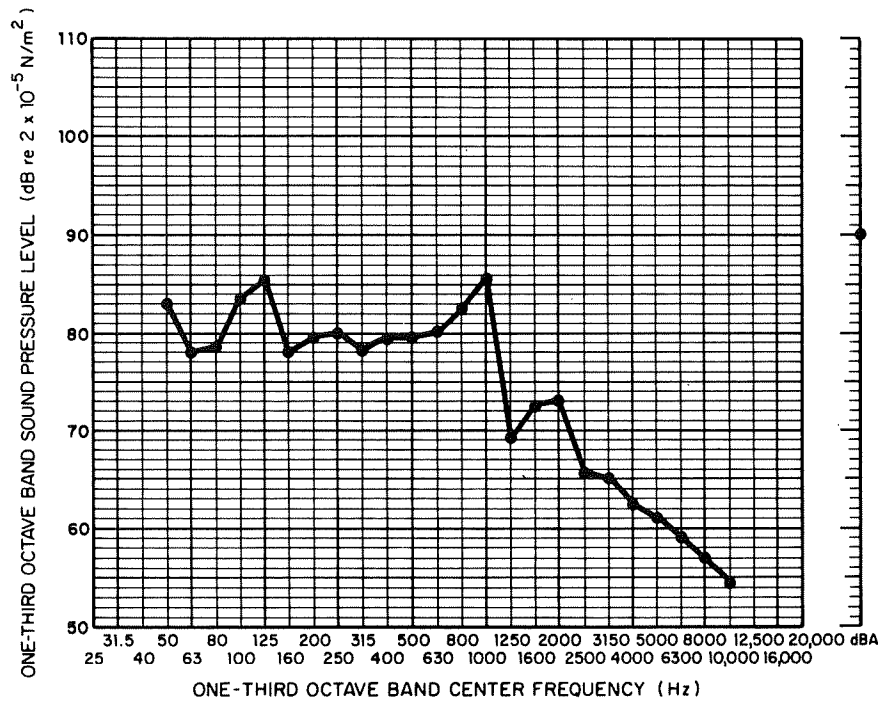


FIG. 19. SOUND POWER LEVEL MEASURED IN MAINTENANCE SHOP (BUILDING B, LEVEL 8).

Figure 20 shows the 1/3-octave band sound spectrum measured alongside a rail car being unloaded (not in control booth) during the shakeout operation [105 dB(A)]. Also shown in this figure is the spectrum measured at the same location during the rotary dump operation. The A-weighted sound level during this operation was 85 dB(A).

The operator in this location was provided with a booth for hearing protection. The sound level in this booth was less than 90 dB(A) during either operation. Even though workers are stationed here for entire shifts, the unloading mechanisms (particularly the mechanical shakeout) do not operate continuously. Therefore, the area is classified as Type II.

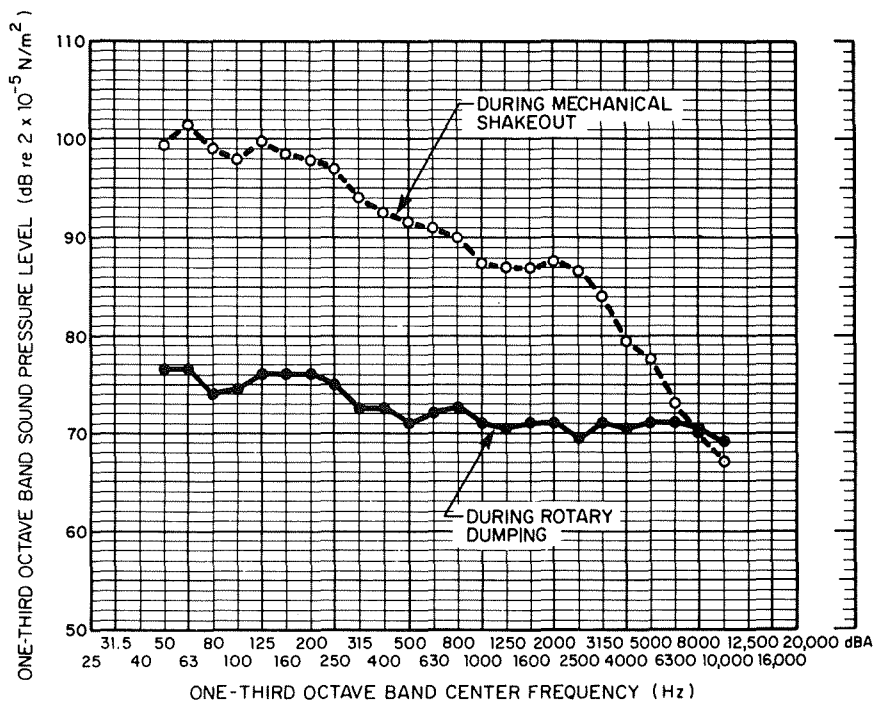


FIG. 20. SOUND POWER LEVELS MEASURED AT OPERATOR'S POSITION IN RAIL CAR UNLOADING AREA.

APPENDIX C: NOISE CONTROL TREATMENTS

C.1 Primary Shaker Screen

Two types of "low noise" screen decks were experimented with on the primary shaker: (1) a normal steel screen backed with 1/4-in. EAR*-damping material; (2) a polyurethane-clad steel screen obtained from Laubenstein. The original steel screen decks for this shaker were 1/2-in. punch plate with 4- and 6-in. diameter holes. The 4-ft x 10-ft steel screens cost roughly \$375 each and required 2 men working 3 hours each for complete replacement. The service life of the original steel screen was about 2 years.

C.1.1 Damped screen deck

Treatment Description

The EAR-backed screen was a single experimental panel installed primarily to determine its suitability in terms of service life. Figure 21 shows the screen panel (bottom up) prior to installation. The 4-in. holes in the damping material were carefully punched and trimmed to match those on the steel deck. The

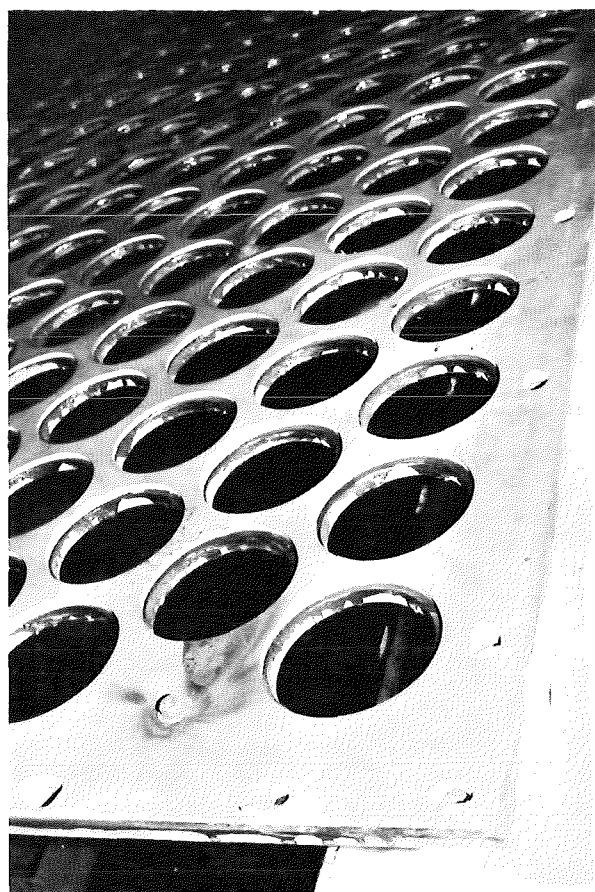


FIG. 21. STEEL SCREEN WITH EAR DAMPING MATERIAL APPLIED TO BOTTOM SURFACE (SHOWN EAR SIDE UP FOR DETAIL).

*All commercially available materials referenced are listed with the names of their manufacturers in Appendix D.

damping material was bonded to the bottom of the steel deck with adhesive and then bolted for added strength. The panel had the same outside dimensions as the original steel deck; the thickness was 3/4 in. This treatment was purely experimental, using an ordinary steel screen and damping material available from other projects within the plant.

Installation

Since the screen had the same nominal dimensions as the original all-steel decks, the installation procedure and time requirements were the same as for the original decks; i.e., there were no modifications necessary in the supports.

Service Life and Maintenance

The screen was installed on 26 July 1976. After approximately 1 month of service, the damping material began to separate from the steel screen. After 2 months of service, approximately 50% of the EAR material was torn from the steel deck (see Fig. 22). Once the separation began, it progressed rapidly.



FIG. 22. EAR-DAMPING MATERIAL TORN FROM UNDERSIDE OF STEEL SCREEN (CENTER).

No maintenance was performed, and no maintenance costs were incurred.

Performance

Since only one panel was installed and since it deteriorated so rapidly, no measurements of the acoustical performance were performed. The use of this screen did not affect production. Even while deteriorating, no significant effect on production was observed. After separation of the damping material from the steel (about 440,000 tons), the remaining service life of the steel deck should be identical to the original deck. As a result of the rapid deterioration, this method was not given further consideration during this project.

Cost

The materials used for this experimental screen were available at the plant. No charge was incurred for the bonding of materials, and there were no maintenance charges. Installation time was the same as for the original steel deck, and since the panel is expected to last as long as the original deck, no increase in cost above normal installation can be identified.

Comment

These results indicate that bonding damping sheets to screen decks is not presently an effective solution. Extensive engineering is required to develop a treatment with good service life. Although a "sandwich" construction (where the damping material is bonded between two steel punch plates) is a theoretical possibility, its noise reduction potential (there will still be noise generated at the point of coal/coal, coal/screen impacts) would

have to be balanced against the costs (manufacturing, blinding caused by thickness, etc.).

C.1.2 Resilient screen deck

Treatment Description

The second type of screen installed was a 3/8-in.-thick steel deck with a 3/8-in.-thick layer of Tuffgard-80 durometer polyurethane bonded to the top surface. Screens of this type could not be made in the original 4-ft × 10-ft size, so 5-ft × 4-ft panels were used.

Installation

The installation time for the resilient decks was approximately 35% greater than that required to install the steel decks, because the mounting brackets and supports had to be adjusted to allow for the thickness and overall changes in size. However, the change in the screen supports is expected to be a one-time change and actually the mechanics found the 5-ft × 4-ft panels easier to handle than the 10-ft × 4-ft steel decks. The actual installation procedure (i.e., bolting to mounting brackets) was the same as for the original steel decks.

Service Life and Maintenance

The urethane-clad screens were installed on 12 and 14 July 1976. Within several weeks after installation, the resilient layer began to separate from the steel deck at the leading edges of the holes. After 2 months of use, the separation became quite apparent (see Fig. 23). After 4 months, or 907,000 tons of infeed, the separation became sufficient to impede the material flow and require removal. The separation of the layers, which

occurred prior to signs of significant wear of the rubber, appears to be the major limiting factor in determining the service life of these large-hole screens. Since the screens were removed and not repaired, no real maintenance costs were incurred.

Performance

Sound level measurements taken alongside the primary shaker before and after the installation of the 4 resilient screen panels demonstrate a 3- to 4-dB reduction in the A-weighted sound levels in the adjacent walkway.

Until the lifting of the rubber layer began to

interfere with the product flow, the production was not affected by the use of the screens. Removal after 4 months of service was necessitated by separation of the layers, not by wear of the resilient top layer. The original steel screen life was about 2 years.



FIG. 23. SEPARATION OF TUFFGARD-80 DUROMETER LAYER FROM STEEL SCREEN AFTER 2 MONTHS OF USE.

Cost

Based on a 4-month service life (attributable to bonding limitation), the annual operating cost of these 4 screens is approximately \$8520 vs \$475 for the corresponding steel screens. This cost is equivalent, in this location, to \$0.313 per hundred tons of raw coal for the resilient decks vs \$0.018 per hundred tons infeed for the steel decks.

Comment

It should be pointed out that this primary screen area is an extremely tough application for such resilient materials, a point that was brought out by the supplier prior to installation of the resilient decks.

C.2 Picking Table

Treatment Description

Several flat resilient impact pads of 1/2-in.-thick Goodyear Armaplate were installed on the picking table to reduce the noise generated when large rocks and coal chunks drop from one level to a lower level on the picking table. Most important was a 1-ft × 2-ft impact pad located several feet upstream of the picking table operator (see Figs. 24 and 25). Goodyear Armaplate has a resilient top surface of 60-durometer rubber that is bonded to a 16-gauge mild steel sheet. Armaplate costs about \$5.60/sq ft for the 1/2-in. thickness.

Installation

Originally, the Goodyear Armaplate was sent out to the main maintenance shop to be cut with a power saw; however, after working with this material in several applications, the mechanics at

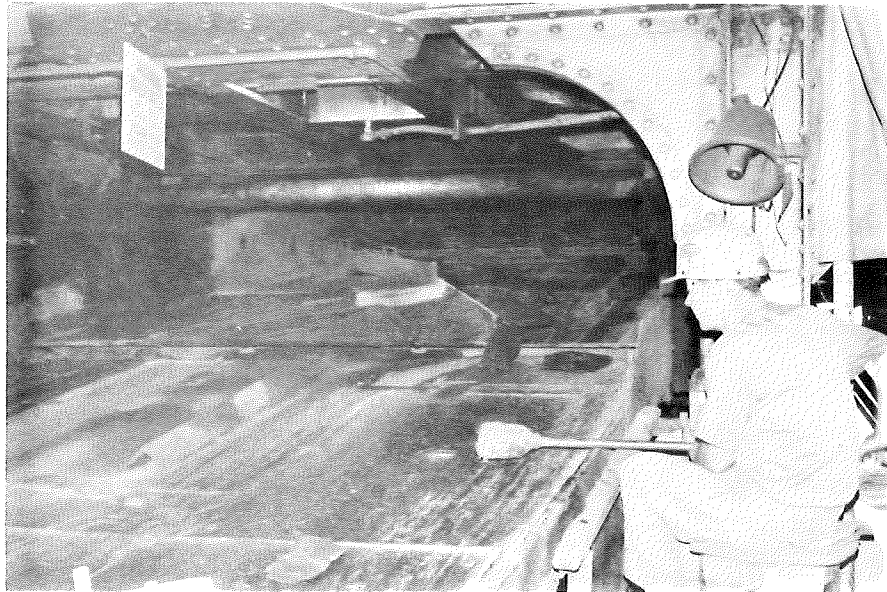


FIG. 24. PICKING TABLE AND OPERATOR (GOODYEAR ARMAPLATE PAD IN CENTER).

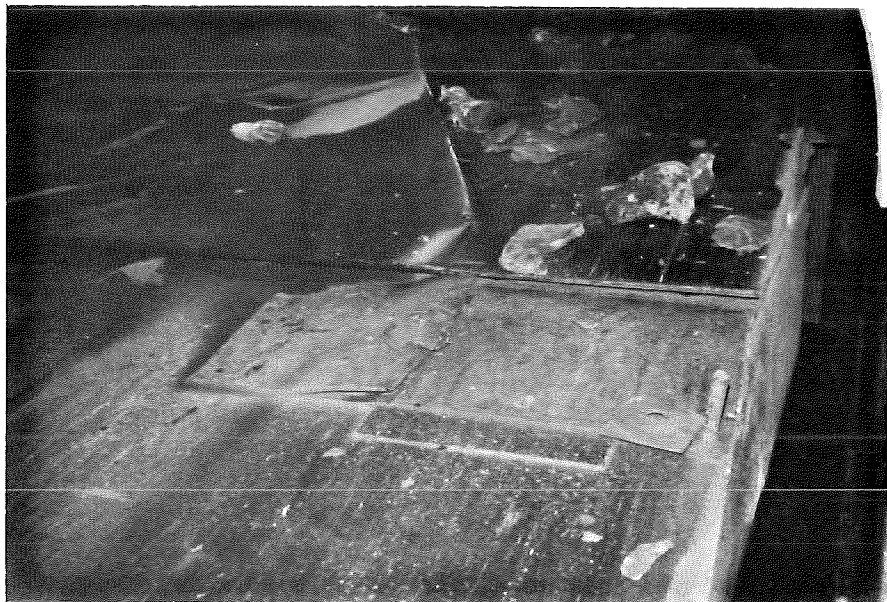


FIG. 25. CLOSE-UP OF GOODYEAR ARMAPLATE (1/2 in.) IMPACT PAD ON PICKING TABLE.

the Georgetown Plant found that they could cut the material effectively by cutting through the rubber layer with a double bladed circular saw, then using a torch to cut the steel backing (see Fig. 26). When the steel cutting was done carefully, the heat from the torch did not appear to damage the bond between rubber and steel. In this installation, holes were countersunk in the resilient layer as shown in Fig. 27, using the drill auger shown in Fig. 28, and the pad was bolted directly to the table. The 1-ft x 2-ft piece located just upstream of the picking table operator required 2 man-hours for installation.

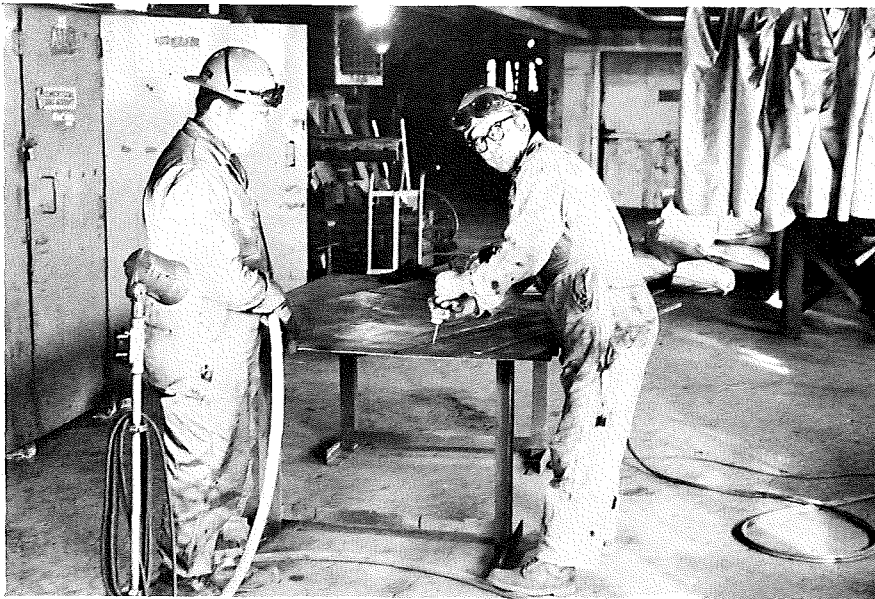
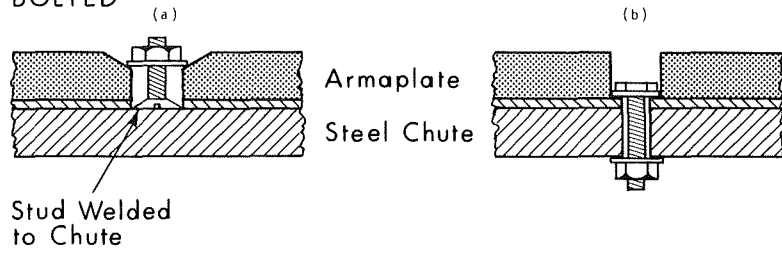


FIG. 26. GEORGETOWN MECHANICS REMOVING REMAINING RUBBER BEFORE TORCHING STEEL BACKING ON 1/2-in. GOODYEAR ARMAPLATE.

In later installations, it was found to be more efficient to tack-weld the Armaplate to the existing steel structure (Fig. 27c) rather than use the bolted arrangement shown in Fig. 27b.

GOODYEAR ARMAPLATE INSTALLATION

BOLTED



WELDED

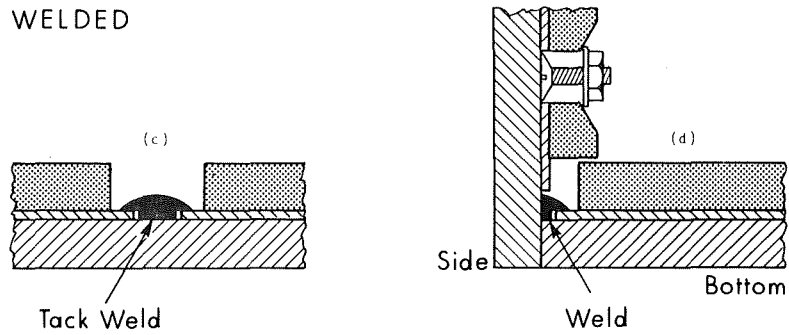


FIG. 27. INSTALLATION OF GOODYEAR ARMAPLATE.

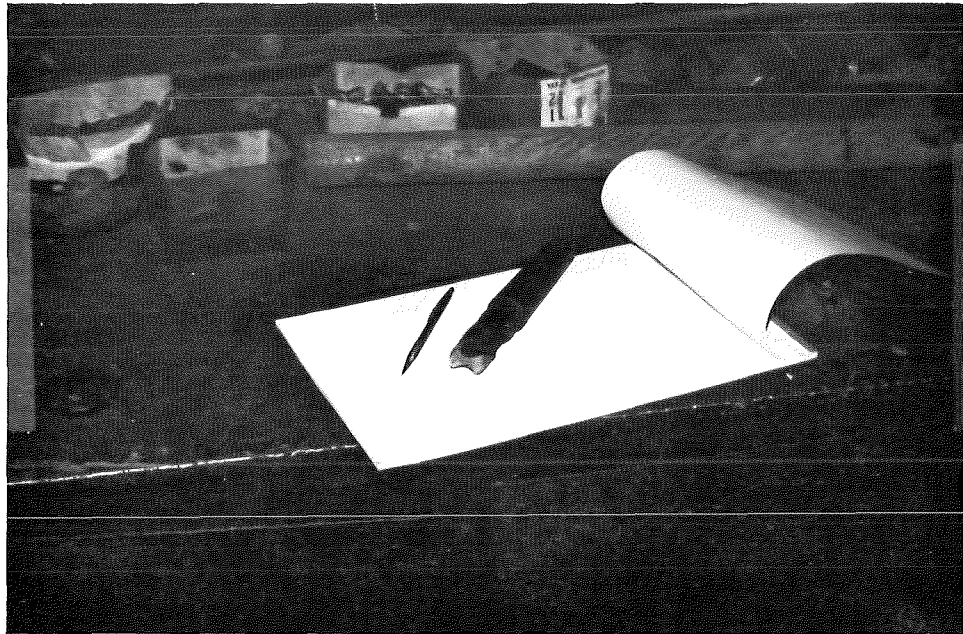


FIG. 28. DRILL AUGER USED TO COUNTERSINK HOLES IN GOODYEAR ARMAPLATE.

Service Life and Maintenance

The 1-ft × 2-ft Armaplate pad was installed on 29 January 1976. After approximately 9 months of use, the resilient top layer had worn sufficiently to require replacement. Apparently, the 1/2-in. thickness was not sufficient to handle the volume of plus-7-in. material at this location.

A second piece of 1/2-in. Armaplate, shown in Fig. 29, was installed at the top of the picking table to receive the material coming off the last primary screen. This material, because of its size, does not receive the density of flow that the lower piece does and, as of June 1977, was still in service. Maintenance for the first piece of Armaplate consisted of pad replacement. A 1½-in.-thick urethane pad was installed.

Performance

The noise reduction at the picking table was 3 to 4 dB(A); however, this result reflects the combined effect of this treatment and treatments of the McLanahan rock crusher infeed chute. The use of the Armaplate pad did not noticeably affect the flow of material over the picking table.



FIG. 29. GOODYEAR ARMAPLATE (1/2 in.) INSTALLED BETWEEN THE TAIL END OF PRIMARY SCREEN AND LEADING EDGE OF PICKING TABLE.

During the 9 months that the 1/2-in. Armaplate was in service, roughly 68,000 tons of plus-7-in. coal and rock passed over the pad. The original steel plate had an *estimated* service life of 3 years. Other than wear, there were no problems with the Armaplate impact pad.

The urethane replacement pad was installed on 6 November 1976 and as of 23 June 1977 was still operating effectively despite some slight wear.

Cost

Based on the 9-month service life, the 1-ft × 2-ft pad above the picker cost \$0.046 per hundred tons vs an estimated \$0.001 per hundred tons for the original steel plate. Although the 1½-in.-thick urethane replacement pad was extracted from another installation and was not new, an equivalent piece would have cost about \$100. The installation time was the same as for Armaplate (i.e., 2 man-hours), even though the urethane has no steel backing.

C.3 McLanahan Rock Crusher

Treatment Description

Two ribbed resilient impact pads of 2-3/16-in.-thick profiled Trelleborg were installed in the crusher infeed chute to reduce the impact noise generated when large rocks impact the chute walls. The infeed chute walls were nearly vertical with the rocks, making an impact angle of 30° to 60° with respect to the chute walls. This condition was more suitable for ribbed resilient impact pads, which altered the impact angle to be closer to 90°, than for flat pads. The two pieces of Type VP Trelleborg, which had steel channels molded into their back face for mounting

with T-bolts, were approximately 24 in. \times 34 in. The cost of the 2-3/16-in.- (55-mm) thick profiled Trelleborg depends on the mounting configuration and cutting necessary. In this case, the cutting was done by the supplier. The two pieces used at the infeed cost approximately \$540 total.

Installation

The installation consisted of drilling 2 rows of holes for each pad in the infeed chute wall, installing T-bolts in each hole, sliding the pad with the mating T-slot over the bolt heads, and tightening the bolts. Figures 30 and 31 are a sketch of the mounting arrangement and a photo of the actual installation, respectively. The entire installation took 2 men 5 hours. This mounting method was used for all the profiled Trelleborg used in the plant. *As a rule-of-thumb, approximately one T-bolt was used for every square foot of material at the Georgetown Plant.*

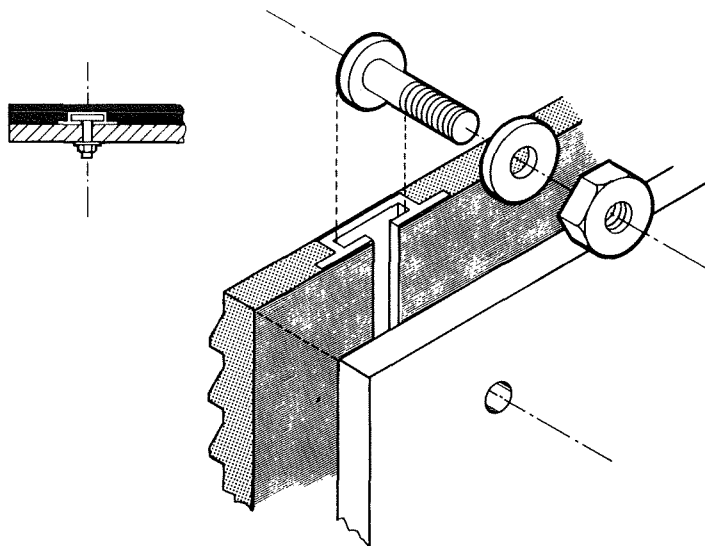


FIG. 30. INSTALLATION OF PROFILED TRELLEBORG IMPACT PAD.



FIG. 31. PROFILED TRELLEBORG AT INFEED TO McLANAHAN ROCK CRUSHER.

Service Life and Maintenance

The two pieces were installed on 4 September 1976 and 15 November 1976. As of June 1977, both pieces were still operational, did not appear to be wearing excessively, and had required no maintenance and no repairs.

Performance

Sound level measurements made above the infeed chute indicate that the use of these resilient pads reduced the impact noise by at least 10 dB to the ambient level above the crusher [92 dB(A)]. Since the chute walls were nearly vertical, the use of the profiled pads did not impede the flow to the crusher. There have been no operational problems as a result of the installation of this material in the infeed chute, and it is too early to judge service life in this location.

Cost

The material cost for the two pieces of Trelleborg was \$540, the hardware cost was \$35 for 10 T-bolts, and the installation required 10 man-hours.

Comment

Two additional pieces of 2-3/16-in.-thick profiled Trelleborg were installed in the outfeed chute from the McLanahan crusher. The first piece was installed at the bottom of the vertical drop under the outfeed of the crusher on 21 August 1976. Because of the shallow angle of the chute (about 30°), the ribbed pattern of the profiled Trelleborg severely obstructed the refuse flow. As a result, the piece was removed on 22 August 1976. Use in such nearly horizontal impact points is, in general, not recommended.

The second piece of profiled Trelleborg was installed on a vertical chute wall downstream of the piece described above (see Fig. 32). At this location, rocks strike the chute prior to dropping onto the refuse belt below. Installed on 21 August 1976, the pad was positioned incorrectly and had to be replaced on 27 November 1976. During an inspection on 13 April 1977, it was observed that the bolts had loosened under 4½ months of refuse impact and that the Trelleborg had slipped. It is recommended for future installations that either the top of the T-slots be welded closed or an angle iron be bolted below the Trelleborg to prevent sliding.

C.4 Secondary Sizing Screens

Several types of resilient screen decks were experimented with to determine their suitability as replacements for the original steel top decks on these screens. The original steel

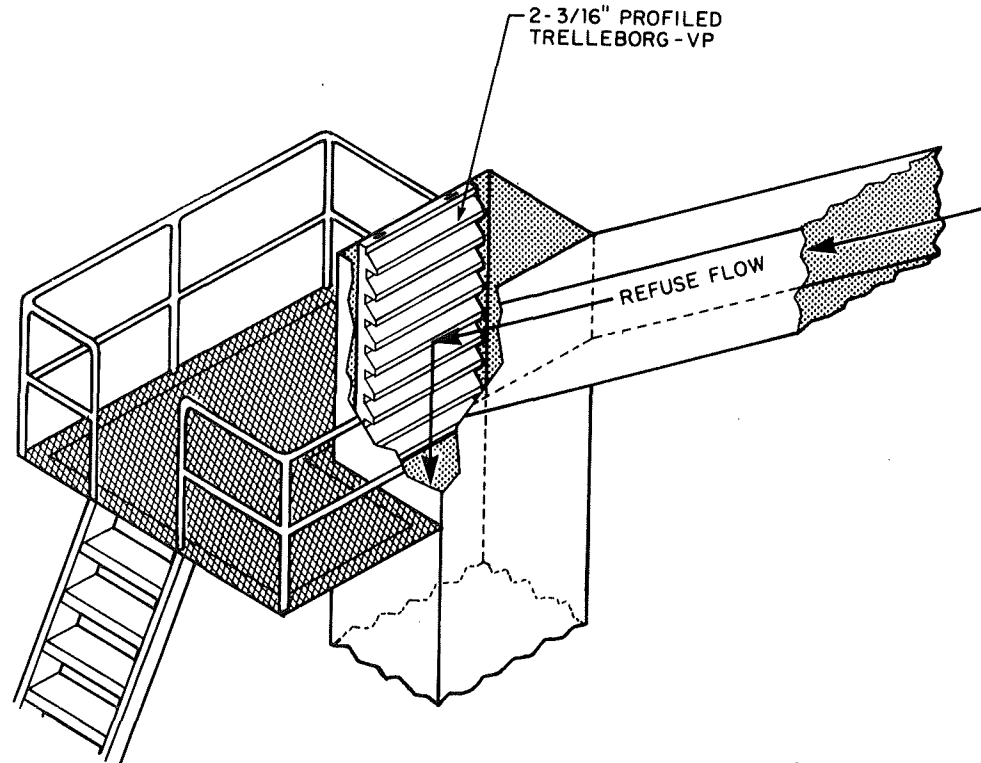


FIG. 32. PROFILED TRELLEBORG INSTALLATION IN REFUSE CHUTE, BELOW McLANAHAN ROCK CRUSHER.

screens were 1/4-in.-thick punch plate with 1 $\frac{1}{4}$ -in.-diameter holes on 1 $\frac{3}{4}$ -in. centers. At a location comparable to where the resilient screens were tried, the steel screen life was 15 months, or 1.65 million tons. Other noise control treatments in this area include Goodyear Armaplate lining for the discharge chute from each shaker to the McNally jigs and, because the resilient screens experimented with did not prove to be a suitable treatment in this location, lead-vinyl curtains around the shakers.

C.4.1 Trelleborg resilient screen deck

Treatment Description

The first resilient deck to be tried on these shakers was an all-rubber Trelleborg deck (see Fig. 33), as opposed to a deck

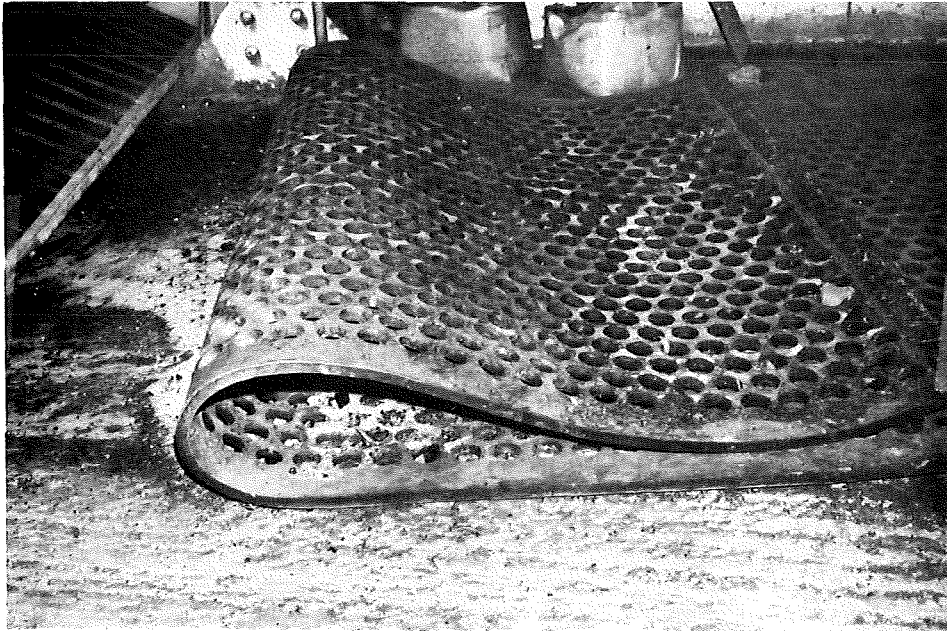


FIG. 33. TRELLEBORG ALL-RUBBER SCREEN.

composed of a resilient layer bonded to the top surface of the steel punch plate. Actually, the screen was composed of a top surface of Trellex-60 rubber and a lower surface of higher durometer rubber for support; this combination is referred to as Duenero rubber. The screen had $1\frac{1}{4}$ -in.-diameter holes, as in the steel deck, but was $\frac{3}{4}$ -in.-thick, as opposed to the $\frac{1}{4}$ -in.-thick steel screen. The single 95-in. \times 47 $\frac{1}{2}$ -in. screen cost \$1180.

Installation

This all-rubber deck required additional support cross braces, as well as some minor changes in the brackets that secure the screen to the shaker sidewalls. As a result, the installation of this first screen required 2 men for 5 hours, as opposed to 2 men for 2 hours for the steel screens. It is reasonable to

assume, however, that once the adjustments are made, the replacement time should be less of a factor for the Trelleborg screens. However, plant personnel felt that the flexibility of the screens required a change in their screen positioning methods.

Service Life and Maintenance

The single test panel was installed on 18 October 1975. On 31 October 1975, the screen was removed because of excessive blinding, which reduced the screening efficiency by roughly 50%. The screen was reinstalled by Trelleborg engineers, who used an improved clamping arrangement and supports that blocked fewer holes. However, these adjustments did not significantly reduce the blinding and the screen was finally removed on 20 January 1976.

Performance

Since only one panel was installed for serviceability testing, no sound level data were obtained. It is expected, however, that all-resilient screen decks should provide at least as much noise reduction as the composition decks discussed later. Because of its early removal, no estimate can be made of its wear life. Blinding was the obvious operational problem, especially in this location where the full screening potential of these shakers is required. Plant personnel indicated that care should be exercised when welding near the screen.

Cost

The initial cost of the single test panel was \$1180 or about \$37 per sq ft vs approximately \$6 per sq ft for the original steel screen. The installation time for the panel was 2½ times

that for replacement of steel decks. However, after the required change in mounting brackets and supports, the installation time would be expected to be comparable to that for steel decks.

C.4.2 Urethane screen deck

Treatment Description

This urethane screen, obtained from McBride Industries, was 1-3/16-in.-thick solid urethane with 1¼-in.-diameter holes. Cost of the 95-in. × 47½-in. test panel was \$795.

Installation

The support brackets had to be lowered to accommodate the increase in screen thickness. Installation time, including modification of the brackets, was 2 men, 4 hours. The plant personnel felt that, even with the one-time support adjustment, time required for screen replacement may still be slightly longer than that for replacing a steel deck, because the flexibility of the all-resilient screen made it somewhat awkward to handle.

Service Life and Maintenance

The test panel was installed on 18 November 1975. Within one week of operation, significant blinding had occurred (Figs. 34 and 35). The blinding became severe enough, with roughly 65% of the holes plugged, to require the removal of the screen on 17 December 1975. There was no actual maintenance required during this one month of service; the holes were not unclogged by hand at the end of the shift.

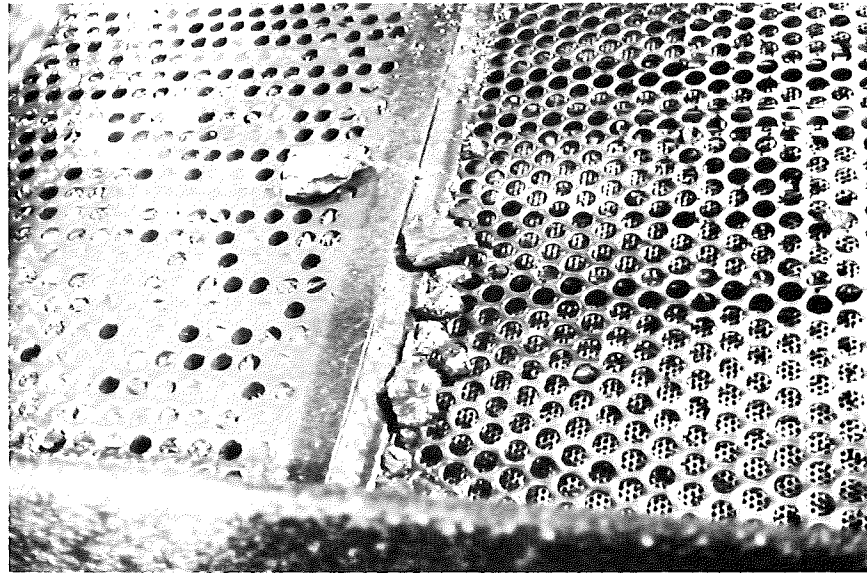


FIG. 34. EXCESSIVE BLINDING OF URETHANE SCREEN (UPSTREAM EDGE).

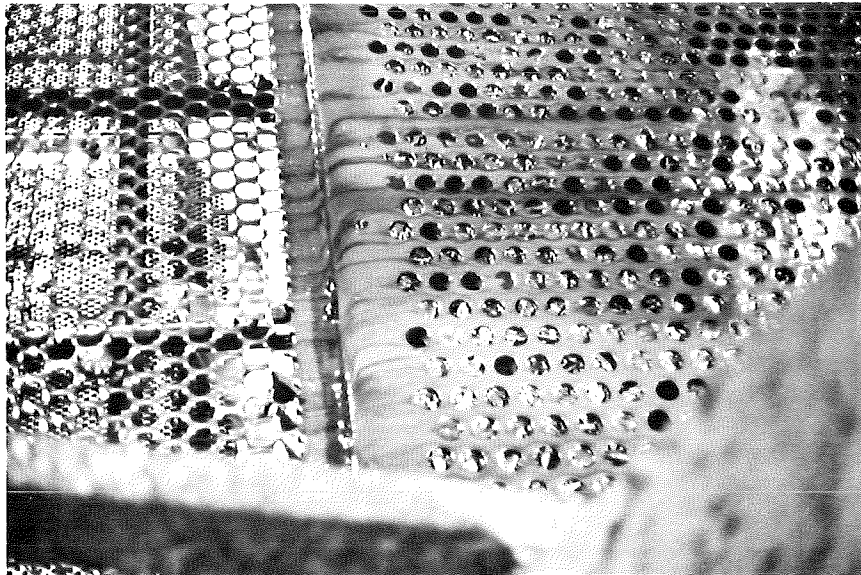


FIG. 35. BLINDING OF URETHANE SCREEN ON SECONDARY SHAKER AFTER ONE WEEK OF OPERATION (DOWNSTREAM EDGE).

Performance

Since only a single test panel was installed in one of the secondary shakers, no sound level data were obtained. Blinding reduced screening efficiency by roughly 65%, thereby necessitating removal of this panel. As a result, no wear-related service life data are available.

Cost

The single screen cost \$795, and the installation time was 8 man-hours.

C.4.3 Hendrick rubber-clad screen decks*Treatment Description*

Two rubber-clad steel screen panels, perforated by Hendrick Manufacturing Company, were installed halfway along the No. 2 secondary shaker to test their suitability in this installation. The screens had a 3/8-in.-thick layer of 60-durometer rubber bonded to the top surface of a 3/16-in.-thick steel punch plate. The holes were 1¼ in. in diameter, and the overall panel dimensions were 95 in. × 47 in. The total cost for the two panels was \$1380.

Installation

The mounting brackets on the shaker sides again had to be lowered to accommodate the increased thickness of the screen. The first-time installation for these panels, 2 men for 4 hours each, was approximately double the installation time for the original steel screens. Part of this increase in installation time can be attributed to the fact that the mechanics were able to slide the original steel decks down from the head end of the

shaker and rotate them into position, a procedure made difficult by the width of the flanges on the resilient decks.

Service Life and Maintenance

The two panels were installed on 22 January 1976. They performed reasonably well for approximately 5 months after installation, with the amount of blinding within the acceptable range for this shaker (10 to 15%). After approximately 5½ months of operation, the forward edge of the upper screen began to show some separation between the rubber and steel plate. In addition, one worn patch appeared on the upstream side of the screen. At the end of 6 months of service, the upper screen was reversed so that the worn areas were now on the downstream side (Fig. 36). This servicing required 2 men for 1½ hours. Over the next 6 months,

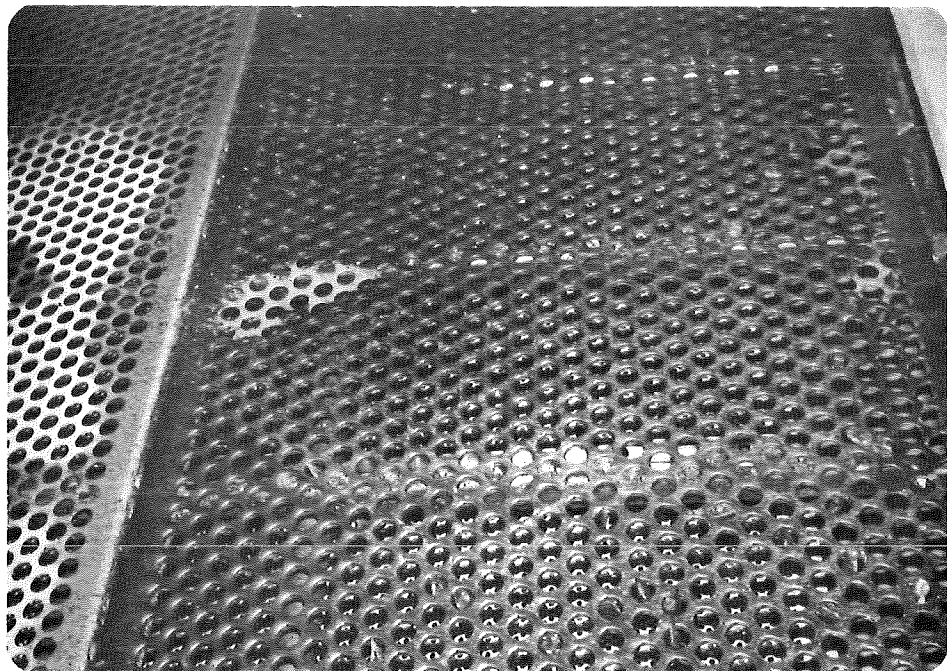


FIG. 36. HENDRICK RUBBER-CLAD SCREEN DECK ON SECONDARY SHAKER AFTER ROTATING AND REINSTALLATION.

the rubber layer both wore away and was torn away (possibly a separation problem), until less than 35% of the rubber remained after 1 year of use.

Performance

Since only two test panels were installed for durability testing, no sound level data were obtained; however, these resilient screens are expected to provide a noise reduction comparable to that obtained on the Rip1-Flo and classifying screens. The screen life for the rubber layers on the panels was approximately 11 months, compared to about 13.5 months for the original steel decks. The reduction in service life, therefore, is about 18.5%. Although the steel screen that remains after the rubber is torn away is still useful (for screening), it provides no noise reduction.

Cost

When the material costs, installation costs, the cost to rotate the resilient panel, and a useful service life of 11 months for the rubber layer, were taken into account, the total cost for the two rubber-clad screen panels on shaker No. 2 was \$0.13 per hundred tons vs \$0.03 per hundred tons for the two original steel decks.

Comment

Of the three screen decks evaluated, two were all-resilient installations and one was rubber-clad steel. Both of the all-resilient screens had a major disadvantage in their susceptibility to blinding, although they are advertised as having performed very well in other industrial applications. The excessive

blinding experienced on the secondary sizing screens may, therefore, be at least partially attributable to the fact that the crank-arm mechanism used on these shakers does not provide sufficient "throw" either to allow the coal to "work" its way through the screen holes or to release it.

Although high initial cost is also a disadvantage, the noise reductions provided by all-resilient screen decks are expected to be significant. At this time, the suitability of such decks in coal preparation plants is questionable.

The third panel, a rubber-clad steel screen, has the same disadvantage as the composite screens evaluated on the primary shaker. The observed separation of the rubber and steel layers results in rapid wear and deterioration. That is, the major limitation appears to be in the bonding techniques. Nevertheless, this panel had a useful service life of approximately 11 months.

C.4.4 Goodyear Armaplate chute liner

The open discharge chutes of the secondary screens carry 1½-in. × 7-in. material to the McNally jigs. The coal/coal and coal/chute impact noise of this flow contributed substantially to the noise both around the walkway and in the McNally jig area. Initially, a small impact pad of 1/2-in.-thick Goodyear Armaplate was installed in the bottom of the No. 2 chute to test its ability to absorb the impact of the material as it dropped off the end of the secondary screen without impeding material flow (Fig. 37). This pad performed successfully. It was therefore removed, and both chute bottoms were completely lined with 1/2-in. Armaplate.



FIG. 37. GOODYEAR ARMAPLATE TEST PAD AT DISCHARGE OF SECONDARY SCREEN.

Treatment Description

The bottom pans of both chutes were lined with 1/2-in.-thick Goodyear Armaplate, and side rails of 6-in.-high Minaloy were installed along the sides of the chutes to protect the edges of the Armaplate. Minaloy, an ultra-high molecular weight plastic, is currently being marketed as an abrasion-resistant lining. Three sheets of Armaplate (each 4 ft × 10 ft) and 40 ft of 1/2-in. × 6-in. Minaloy were used in this installation. The Armaplate cost about \$5.60/sq ft, and the Minaloy about \$180 total.

Installation

Figure 38 shows the general configuration of the installation. The Goodyear Armaplate was cut to size, and holes were countersunk in the center portion, as illustrated previously in Fig. 27. The Armaplate was bolted onto the bottom of the chute.



FIG. 38. LINING OF DISCHARGE CHUTES OF SECONDARY SCREEN.

The Minaloy side rails were bolted to the chute walls to prevent coal from being forced below the Armaplate or between the resilient layer and steel backing. The installation time was 4 man-shifts for both discharge chutes. This compares with 8 man-shifts for complete replacement of the chutes, whose bottom pans are 1/2-in. mild steel.

Service Life and Maintenance

The chute from the No. 2 secondary screen was lined on 25 September 1976; the chute from the No. 1 secondary screen, on 6 November 1976. The flow in these chutes averages 400 tph of 1½-in. to 7-in. raw coal with approximately 35% rock. The Armaplate began to show signs of significant wear within 4 months and was considered worn out within approximately 6 months after installation. This period is only about half the expected life of the steel chutes.

Performance

The chute lining was installed after curtains were placed around the discharge chutes and secondary screens. It was difficult, therefore, to get an accurate measurement of the acoustical effectiveness of the chute linings. However, on the basis of the values for sound buildup measured at the other curtain installations, the noise reduction afforded by the Armaplate chute liners in this location is estimated to be 1 to 2 dB. This small noise reduction indicates that the coal and rock impacting on themselves were the major source of the noise radiated out of the open top of the chute to the catwalk, where the measurements were made. The Armaplate did not interfere with the flow of the material through the chutes, nor was any specific repair performed prior to the materials wearing out. Since the lining provided only minimal noise reduction (especially considering the effect of the curtains), it was not replaced.

Cost

The operating cost of the two Armaplate-lined chutes was \$0.36 per hundred tons vs an estimated \$0.14 per hundred tons for the original steel chutes. The corresponding annual costs are \$2375 for Armaplate and \$940 for steel for the two chutes.

Comment

In view of the high cost and low noise reductions, consideration is being given to covering the chutes rather than relining them.

C.4.5 Lead-vinyl curtains

Treatment Description

Lead-vinyl curtains were installed around the secondary shaker screens to reduce the noise radiated by these screens to Level 5 of the plant, and to reduce the noise exposure of workers who pass by the screens on their way to the adjacent plant areas. The curtain material, supplied by Singer Partitions, had a surface density of 3/4-lb/sq ft. The amount of material used in this installation was approximately 1490 sq ft, at a cost of \$4790 for the curtain material and \$1585 for hardware, which included Velcro™ tape. The curtains came with the Velcro strip fasteners preinstalled (stitched) on the curtain panels.

Installation

The installation required 2 men 5 shifts and involved the installation of both stationary (Fig. 39) and movable (Fig. 40) panels. The stationary panels extended over two levels and served to block the noise of the discharge chutes from radiating to the washbox area in Level 5. These panels were installed



FIG. 39. STATIONARY CURTAIN PANELS INSTALLED AT DISCHARGE SECTION OF SECONDARY SHAKERS.

by bolting the vinyl directly to the I-beam floor supports (for the lower panels) and hanging the upper section from the standard track and hangers used for movable sections. These panels, however, are not normally opened. The movable panels were installed by cutting straight and curved track sections to size and

- Either welding the track to the existing building structure with mounting brackets supplied by curtain supplier (Fig. 41)
- Or mounting (via welding or bolting) the track to an independent support frame (such as the steel channel in Fig. 42), which is then welded to the existing building structure.

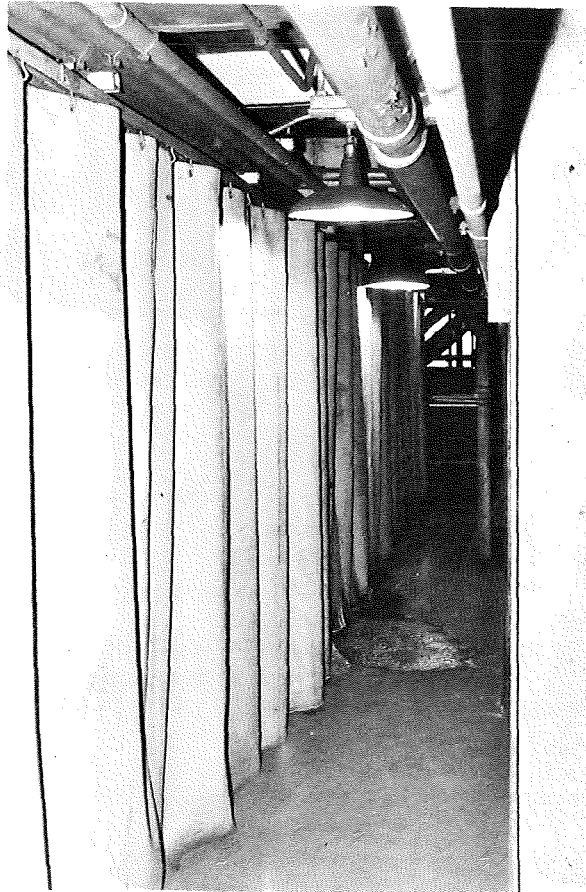


FIG. 40. MOVABLE CURTAIN PANELS INSTALLED ALONGSIDE SECONDARY SHAKERS.

This latter arrangement is better suited to installations where large amounts of curtain material are to be hung, because the greater strength afforded by this method will support more curtain material than will the standard curtain track alone. Because the curtain panels were premeasured and fitted with grommets by the supplier, the majority of the installation time involved the installation of the track. Velcro tape was used to seal the

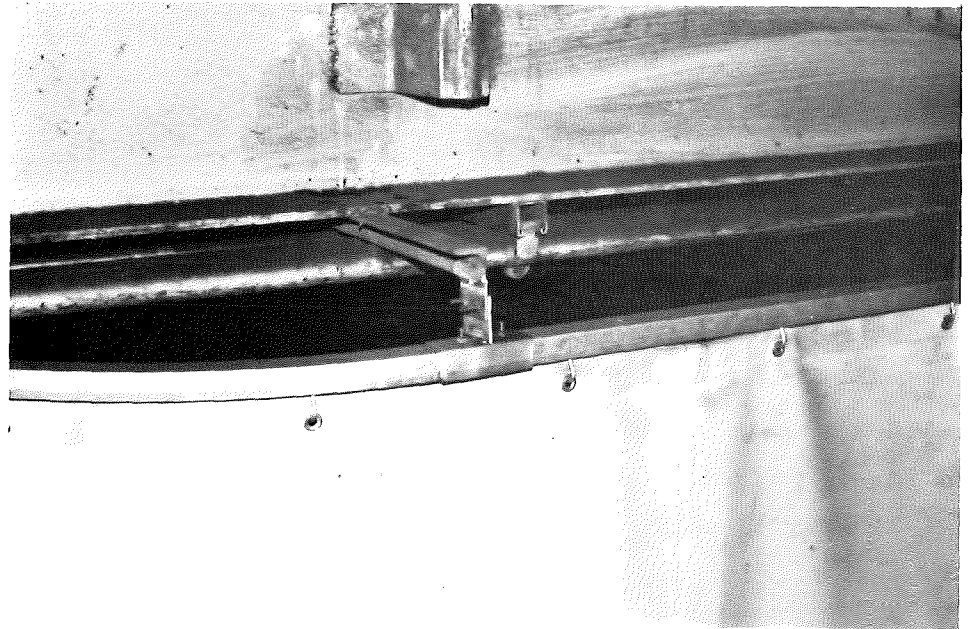


FIG. 41. WELDING OF MOUNTING BRACKETS TO BUILDING STRUCTURE.



FIG. 42. CURTAIN TRACK BEING BOLTED TO STEEL SUPPORT CHANNEL.

curtain panels during use, while allowing them to be opened for access. These tapes were also preinstalled on the curtains by the supplier.

Service Life and Maintenance

The curtains were installed on 22 September 1976, and as of 23 June 1977 no maintenance has been required. The Velcro strips do not appear to fill with dust as quickly as was initially expected.

Performance

Sound level measurements taken before and after installation indicate that the curtains have reduced the A-weighted sound level from 97/98 dB(A) to 93 dB(A), a reduction of 4 to 5 dB(A). The noise reduction is limited by the existence of a 1-ft gap between the top of the curtain track and the ceiling. Sealing this gap with strips of excess curtain material is expected to provide another 2- to 3-dB reduction. Although the curtains eliminate the ability for casual visual monitoring of screen operation, they can be easily opened periodically for this purpose as well as for maintenance of the screens. The ease of moving the curtains out of the way during maintenance operations is one of the major advantages of such curtains over rigid enclosures.

Cost

The cost of the 1490 sq ft of curtain material was \$4790. Additional material costs were as follows:

Quantity	Description	Total Cost
268	2-Wheeled hangers w/1-in. hooks	\$ 645
234 ft	Straight track	365
234 ft (est.)	Channel	155
24	Beam connectors	100
6	Mounting brackets	30
2	Right-angle corner tracks	25
77 ft	Velcro sealing tape	<u>265</u>
		\$1585

Installation, excluding the treatment for the 1-ft gap above the curtains, required 2 men a total of 5 shifts. The total installed costs for this installation were typical of the other installations at the Georgetown Preparation Plant, which averaged \$4.50 per sq ft.

Comment

While the use of curtains does not directly affect production, some employees at the Georgetown Preparation Plant felt that loss of the ability for casual visual monitoring of screen operations does have some indirect effects - for example, not being able to anticipate flow backups. Clearly, some effort must be expended to open the curtains a couple of times during the shift to gain visual access to shaker operation. Later, curtain installations were modified to include clear vinyl windows.

In view of the problems encountered with resilient screen decks, the curtain installations offer a number of advantages: apparent long service life, low maintenance, good noise reduction, and easy access for screen maintenance.

C.5 McNally-Baum Coal Jigs

Four treatments were installed on the McNally-Baum jigs (washboxes): (1) resilient pads in the refuse box, (2) liners in the discharge chutes, (3) covers over the openings in the jig elevators, and (4) mufflers on the blowers that supply pulsating air for the jigs. Figure 43 shows the general configuration.

C.5.1 Resilient impact pads

Treatment Description

As shown in Fig. 43, profiled Trelleborg was installed on the vertical wall in the refuse box to receive the initial impact

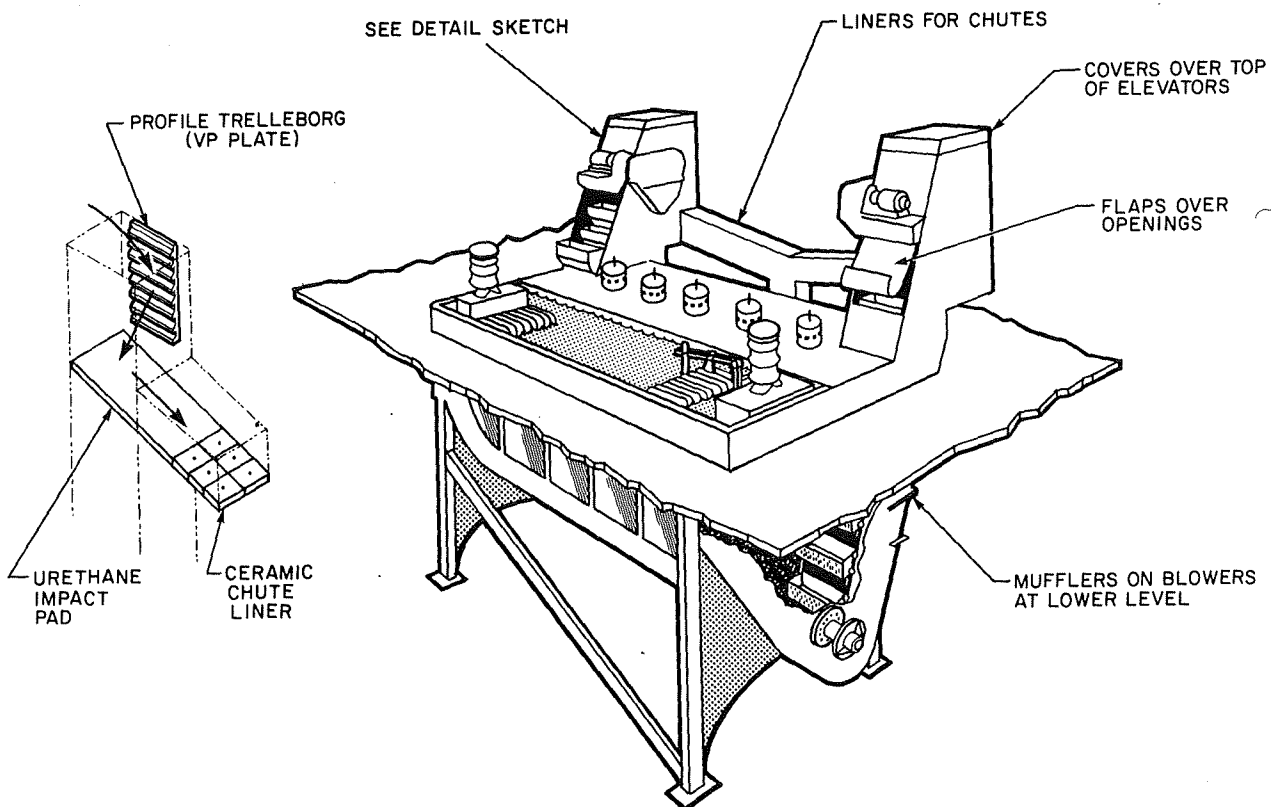


FIG. 43. McNALLY JIG NOISE CONTROL INSTALLATIONS.

of the refuse as it comes off the elevator baskets, while flat urethane pads were installed at the bottom of the refuse box to reduce the impact of the falling refuse prior to its sliding down the refuse chute. Approximately 18.5 sq ft of 2-3/16-in.-thick profiled Trelleborg was used at the No. 2 elevator discharge, at a cost of \$585, or about \$32 per sq ft. The No. 1 discharge required only 13.3 sq ft of material at a cost of \$650. At the bottom of each discharge, 6.2 sq ft of 1½-in.-thick urethane impact pad was used, at a cost of \$33 per sq ft.

Installation

The Trelleborg pads were installed with T-bolts, as previously illustrated in Figs. 30 and 31. The installation required 2 men 1 shift for each of the two discharges. The urethane pads were laid into the bottom of the elevator discharge with their edges held in place by tack-welded steel plates. This relatively straightforward installation required 2 man-hours for each discharge.

Service Life and Maintenance

Profiled Trelleborg was installed 18 October 1975 and 19 June 1976 on the No. 2 and No. 1 refuse elevators, respectively (Fig. 44). As of 23 June 1977, the edges of the material in the No. 2 chute were showing some slight rounding at the impact point; however, the pads were still quite serviceable. No maintenance has been required since installation. The urethane pads were installed on 15 November 1975 and 4 September 1976 in the No. 2 and No. 1 refuse chutes, respectively. Inspection of the pad in No. 2 on 23 June 1977 indicated that the center of the pad, at the impact point, had worn through and that some refuse had pushed up under the pad. This loose material provides some

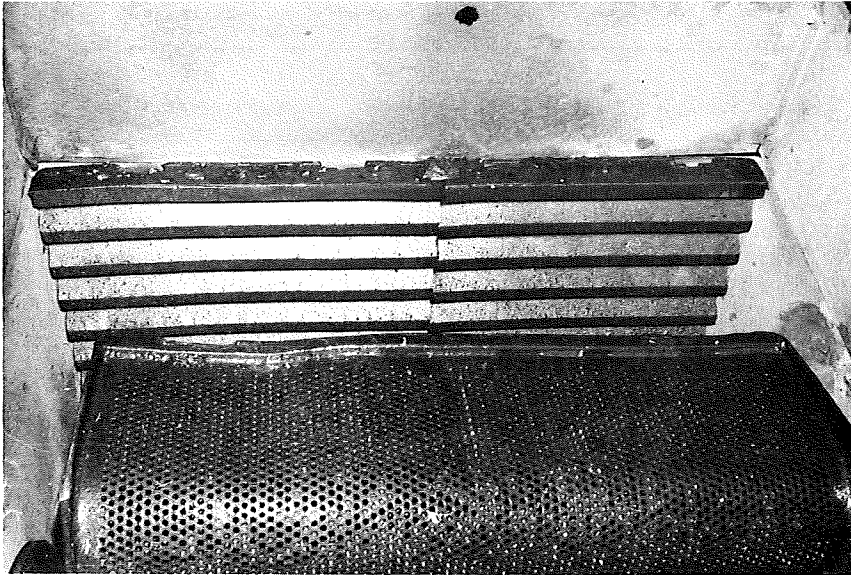


FIG. 44. PROFILED TRELLEBORG BOLTED TO CHUTE WALL OPPOSITE NO. 2 REFUSE ELEVATOR DISCHARGE. (ELEVATOR BASKET SHOWN AT TOP OF TRAVEL.)

cushioning of the impact of the falling refuse. Therefore, while the material technically has been worn through, it is still providing some indirect cushioning.

Performance

The original sound levels measured 3 ft behind the No. 2 discharge were 95 to 97 dB(A) with the plant operating at full capacity. Sound levels measured after the installation of the impact pads were 91 to 93 dB(A), a 3- to 5-dB reduction. A small part of this reduction may be attributable to such treatments as the curtains around the secondary shakers and the covers over the tops of the elevators. The impact pads did not affect the productivity in the jigs. The Trelleborg pads had been in service for about 20 months as of the final inspection on 23 June 1977; the service life of the original 1/2-in. steel plates was 6 to

7 months. When the same final inspection date is used to mark the end of the useful life of the urethane pad in the No. 2 refuse chute, its service life was 19 months, while the original 1-in. steel plate was reported to last approximately 8 months.

Cost

The cost for purchasing and installing Trelleborg pads in both chutes was \$1235 for Trelleborg, \$100 for T-bolts, and 4 man-shifts of labor. As of 23 June 1977, this cost is equivalent to \$0.42 per hundred tons vs an estimated \$0.20 per hundred tons for the 1/2-in. steel. This cost difference will decrease over time, since the Trelleborg is still serviceable. Comparable costs for the urethane pads are \$0.135 per hundred tons vs \$0.145 per hundred tons for the 1-in. steel. The potential for equaling or bettering the cost-per-ton figures for steel while achieving some significant noise reduction makes these treatments quite attractive.

C.5.2 Chute liners

Two different types of chute liners were installed in the discharge chutes from the jig refuse elevators. An ultra-high molecular weight plastic called Minaloy was first installed in the No. 2 jig refuse chute for testing. This liner eventually wore out and was replaced with alumina ceramic tiles. After the ceramic performed successfully in the No. 2 chute for 5 months, it was also installed in the No. 1 chute.

Treatment Description

Initially, approximately 32 sq ft of 1/2-in.-thick Minaloy was used to line the No. 2 chute. The material costs were \$358

for a 40-sq-ft sheet, or about \$9 per sq ft. A total of 80 sq ft of 1/2-in.-thick DurafraxTM ceramic tile (manufactured by Carborundum) was eventually used in both chutes, at a cost of \$10 per sq ft, including grommets and plugs for mounting.

Installation

The Minaloy was bolted to the bottom of the No. 2 refuse chute (Fig. 45). Holes were countersunk in the plastic, so that the boltheads would not obstruct the flow, and the boltheads were burned with a torch to ensure that the bolts would not loosen. The 4½-in.-high steel wear plates that were welded to the sides of the chute also served to hold the Minaloy in place. The total installation effort for this one chute was 2 men for one shift. The ceramic tiles, shown in Fig. 46, were installed with conical metal grommets, which were spot-welded (Fig. 47) to the bottom of the chute, which was cleaned prior to the installation. The



FIG. 45. MINALOY PLASTIC CHUTE LINER IN NO. 2 JIG REFUSE CHUTE.

holes in the grommets were then filled with ceramic plugs. The entire process required 2 men for 1½ shifts for each 26-ft chute.

Service Life and Maintenance

The Minaloy chute liner was installed in the No. 2 jig refuse chute on 8 December 1975. Two and a half months later, on 20 February 1975, the Minaloy was removed because of excessive wear. Apparently, the coarse nature of the refuse (70 tph) and the tendency of the flow to bounce and impact the liner rather than slide over it caused severe gouging. The ceramic



FIG. 46. DURAFLEX CERAMIC TILE INSTALLED IN JIG REFUSE CHUTE.

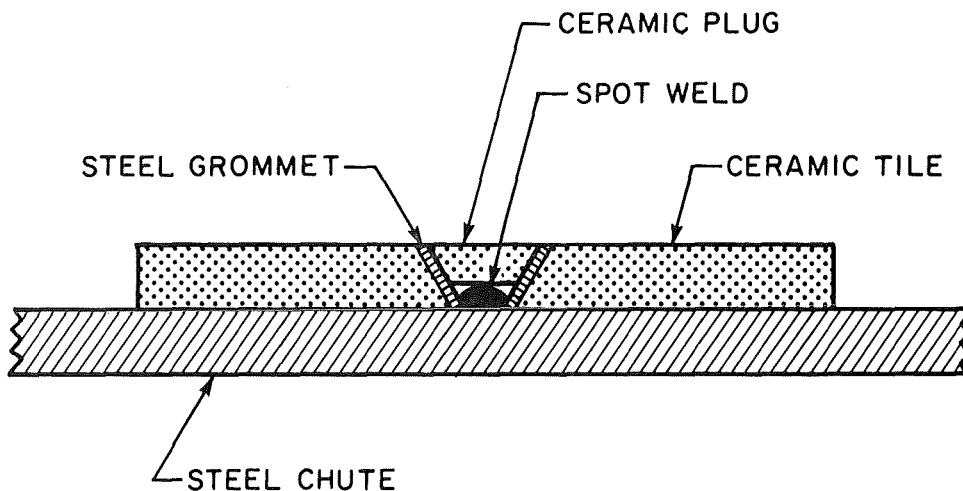


FIG. 47. INSTALLATION OF CERAMIC TILE IN CHUTES.

tile was installed in the No. 2 chute on 31 February 1976 and in the No. 1 chute on 25 September 1976. Between the time of installation and the final inspection date of 23 June 1977, a number of cracks and slight chipping of the tiles had become evident; however, actual wear did not yet appear to be significant. No maintenance was performed on either liner.

Performance

Because the refuse chutes operate only in conjunction with the jigs and were not the major noise source in the area, no independent assessment of the noise reductions obtained with these liners alone was performed. Experience with other open chutes in the plant indicate that the noise reduction achieved by such material is only about 1 to 3 dB and is a function of both the amount of flow and of the location of the chute with respect to the worker. That is, if the worker stands over the open chute, there is a minimal noise reduction. The effectiveness of the ceramic-tile treatment was enhanced by the installation of sheet steel covers over the previously open chutes (see Fig. 48).

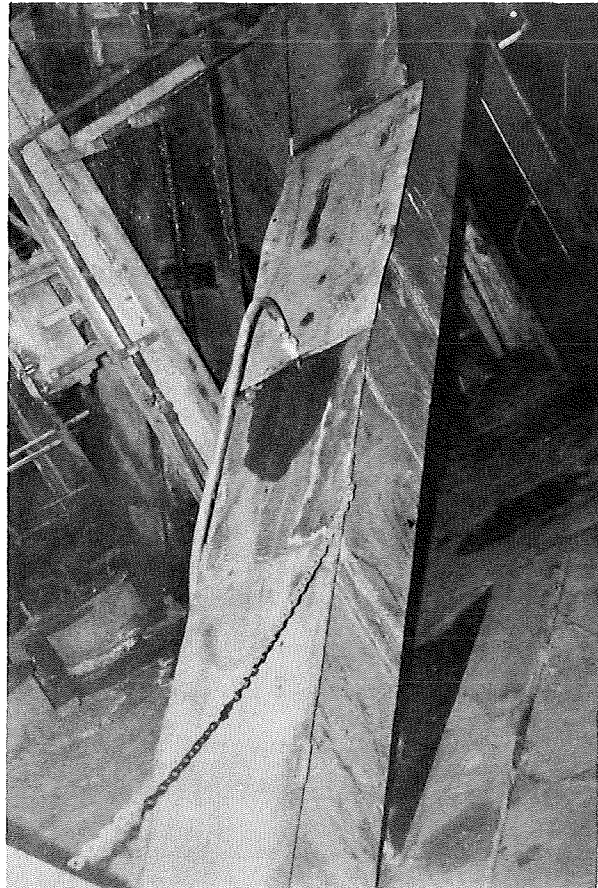


FIG. 48. STEEL COVERS ON NO. 2 JIG REFUSE CHUTE.

Neither liner impeded the flow in the chute; in fact, since neither rusted as would a steel chute when the plants shut down, there was actually less of a tendency for the material to "hang-up" when the jigs resumed operation. As of the final inspection date, the ceramic tile in the No. 2 chute had been in place for 2.3 times the service life of the original steel chute and was still serviceable.

Cost

The Minaloy at \$9 per sq ft cost \$1.80 per hundred tons of flow over the material vs \$0.27 per hundred tons for the original steel bottom. It is too early to determine the final cost per hundred tons handled for the ceramic liner.

Comment

An important point about chute liners is that their installation in existing chutes will reduce the chute area somewhat. Therefore, if the existing chute opening is already used to its capacity, the installation of a new, larger chute may be required.

C.5.3 Flaps and mufflers

Treatment Description

Flaps and covers were placed over the elevator openings. The flaps over the elevator track, shown open in Fig. 49, were made from leftover rubber sheet. The covers over the tops of the elevators were fabricated either from available sheet metal or from rubber. The 2 mufflers on the jig blowers (Fig. 50) are FPS Model 14 mufflers, which were purchased by the Georgetown Plant, prior to the start of this program, for \$517 each.

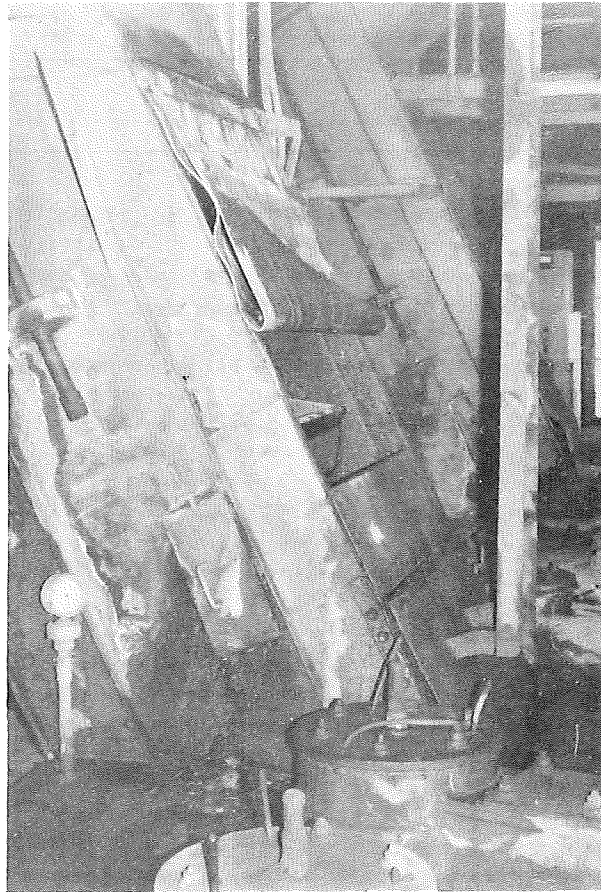


FIG. 49. SHEET RUBBER COVER, SHOWN HELD OPEN, OVER ELEVATOR BASKET TRACK.

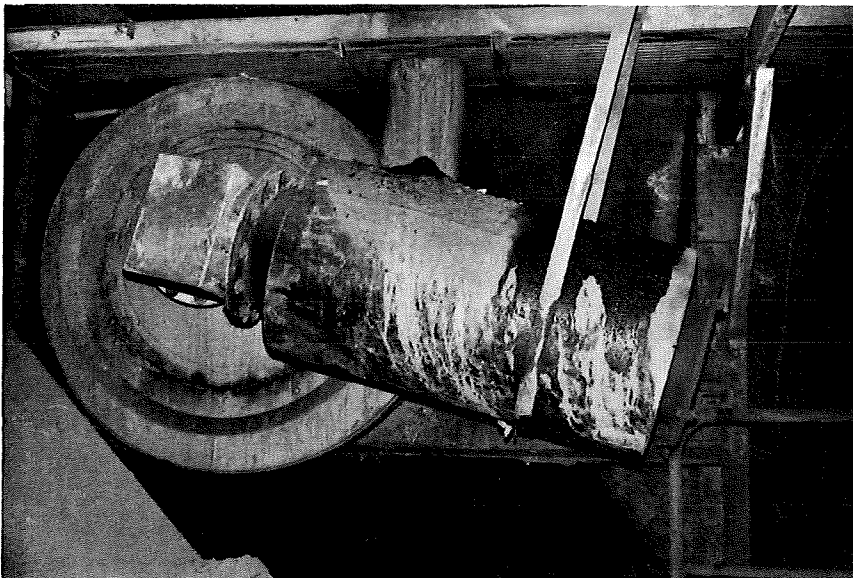


FIG. 50. MUFFLER ON JIG AIR INTAKE BLOWER (BUILDING A, LEVEL 6).

Installation

Installation of flaps, covers, and mufflers required approximately 9 man-shifts. The flaps and covers were cut to size, stitched, and bolted to the chutes.

Service Life and Maintenance

The bolts on one of the sheet metal covers on the jig elevators loosened during use, and, as a result, the bolts were welded to ensure that they would not loosen again and possibly injure someone if, as a result, they fell off their support. No other maintenance was performed.

Performance

Sound levels measured at the coal sampling station were reduced from 99 dB(A) to 92 to 93 dB(A), a reduction of from 6 to 7 dB(A).

Cost

Material costs were a total of \$1035 for the mufflers. Installation costs were approximately 58 man-hours of labor for flaps, covers, and mufflers. No material costs were incurred for the flaps and covers, as they were made from leftover materials.

C.6 Middling Shakers*Treatment Description*

Durasonic-5332 lead completely around the 2 middling vibrators located on Level 5 adjacent to the washboxes (Fig. 51). These curtains were lined with



FIG. 51. CURTAINS INSTALLED AROUND MIDDLEING SHAKERS.

1/4-in.-thick open-cell sound-absorbing foam on the side facing the noise source to limit the buildup of sound energy within the enclosed space while this type of foam tends to accumulate dust, which can be a safety problem, the middling vibrators are not in a dusty area. The curtains, 7½-ft-high, surrounded the perimeter of both shakers, approximately 60 ft. The material cost for the curtains was about \$400, and the hardware cost about \$440. Also installed on the middling vibrators were 3-ft × 1/2-ft resilient impact pads at the discharge end of each vibrator (Fig. 52). The material used was 1/2-in.-thick Goodyear Armaplate, which cost \$5.60/sq ft.

Installation

The curtains were installed on standard track that was bolted to steel channel supports, as previously illustrated in

Fig. 51. The supports were welded to the existing steel I-beams over the shakers. Small sections of angle iron (Fig. 53) were used to strengthen the assembly. The curtain panels were hung from standard hangers, and the top of the enclosure formed by the curtain was left open. Velcro strips running the full height of the curtain panels were used to seal the parting seams during operation, yet allow the curtains to be opened for maintenance. The Velcro was sewn directly to the curtains.

Also installed in the curtains were flexible clear vinyl observation windows (visible in Figs. 51 and 53). Rectangular holes were cut into the curtains, and Velcro tape strips were sewn around the perimeter of the vinyl windows and mating openings. The benefit of this type of installation, which is slightly more complicated than simply gluing the windows in, is the easy removal for cleaning and replacement. The total installation time for the curtain treatment was 3 man-shifts.

The Armaplate installation consisted of bolting the material to existing steel plates.

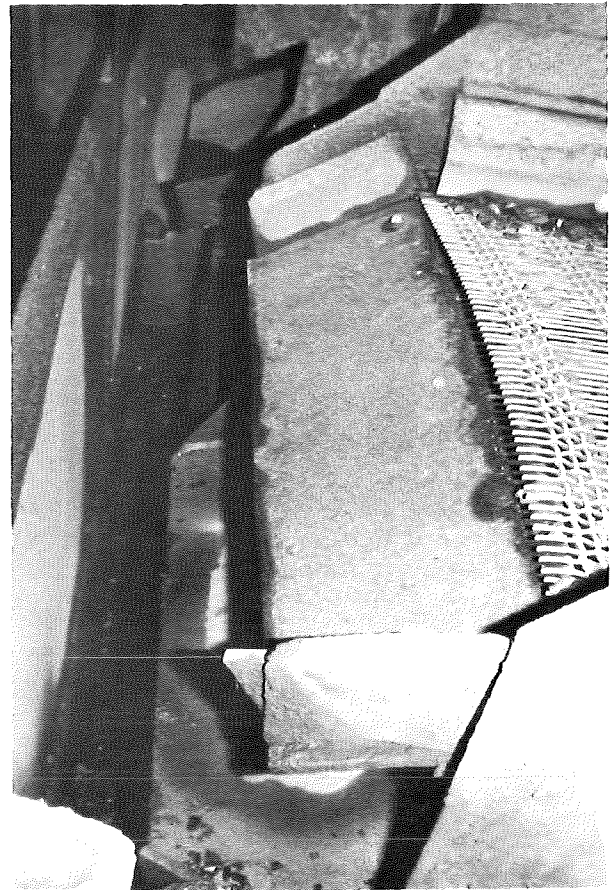


FIG. 52. RESILIENT IMPACT PAD AT DISCHARGE OF MIDDLE SCREEN.

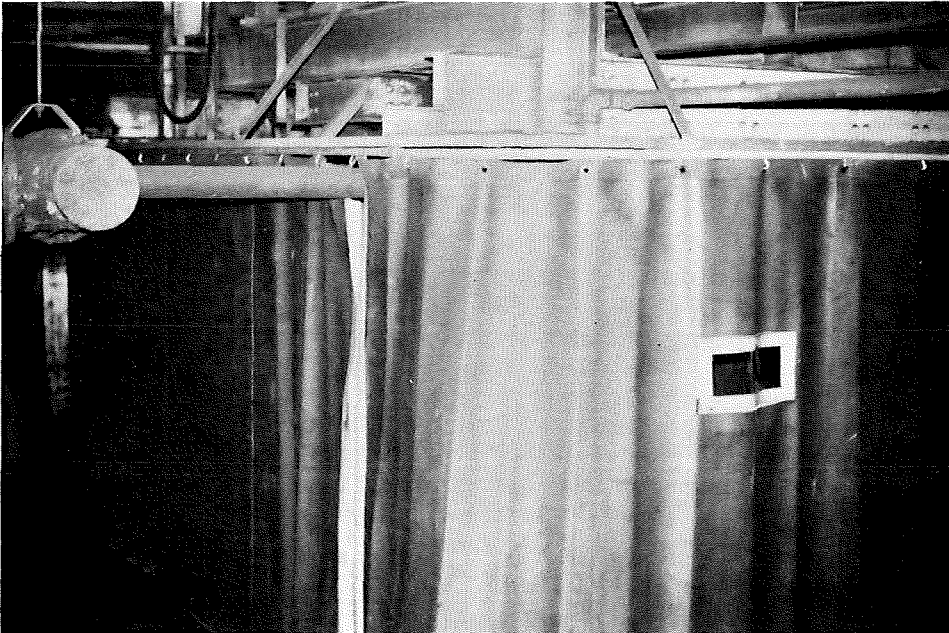


FIG. 53. TRACK SUPPORT FRAME FOR MIDDLING CURTAINS.

Service Life and Maintenance

Both the curtains and impact pads were installed on 30 September 1976. The last inspection of both treatments was on 23 June 1977, at which time both materials were in good condition. No maintenance was performed on either material during this period.

Performance

The A-weighted sound levels measured inside and just outside the curtains, with these shakers operating alone, were 96 dB(A) and 89 dB(A), respectively. Figure 54 shows the sound spectra measured at these two positions; the difference between the two spectra indicates the variation in noise reduction with frequency. The sound buildup within this curtain enclosure (i.e., the increase in sound levels within an enclosure due to the reflection

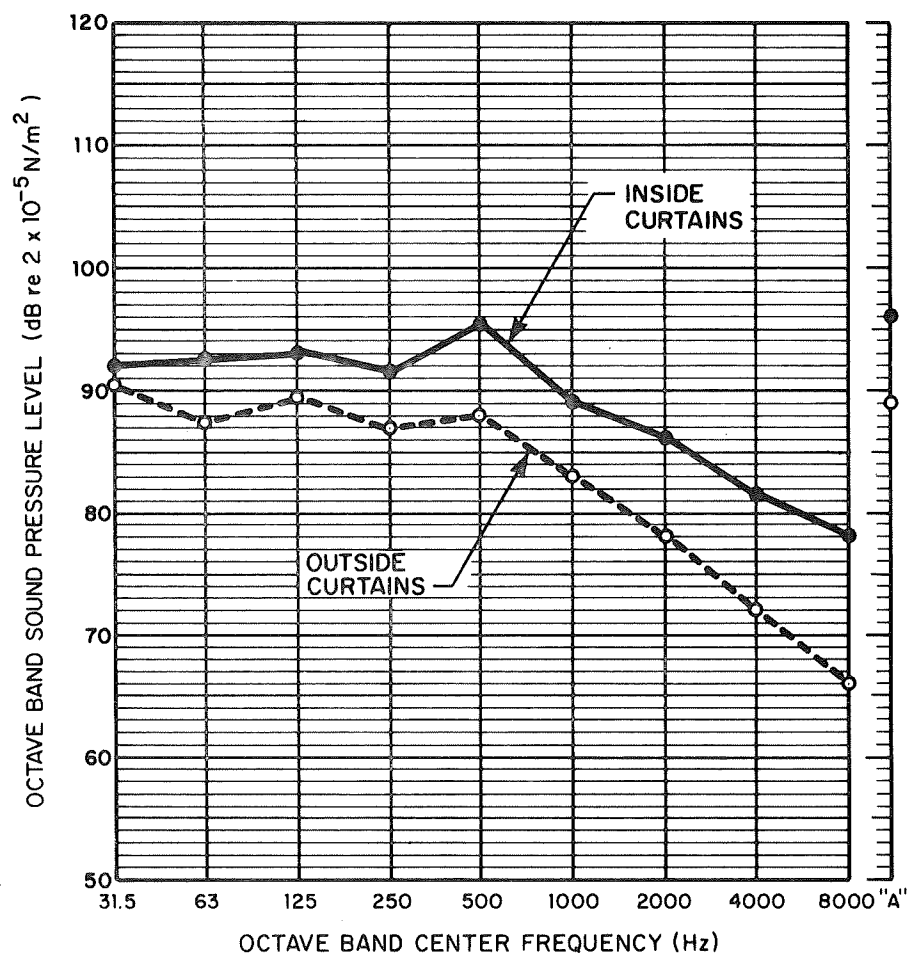


FIG. 54. SOUND PRESSURE LEVELS MEASURED AT MIDLING VIBRATOR CURTAINS.

of sound from the inside curtain surfaces) is minimal because of the unobstructed, open-top construction, and the sound-absorbing foam on the inside surface of the curtains. Without these features, the sound levels within the curtained area would have been higher than the measured 96 dB(A).

No measurements were made of the acoustical performance of the impact pads, because the noise from other sources in the units obscured such evaluation. Installation of the impact pads, therefore, served as a test of the wear-life of this material. The pads, in fact, wore well, but because they were so resilient, some of the 3/8-in. \times 1 $\frac{1}{4}$ -in. material bounced out. Vertical barriers placed at the discharge end of the screens alleviated this problem.

The added bulk of the open-cell foam lining seems to inhibit folding when the curtains are opened. Some commercially available curtains have vertical strips of foam, allowing the curtains to bend at the unlined areas. This type of curtain might prove more convenient here.

Cost

The total curtain cost was \$1060, including installation; the impact pads cost approximately \$55 installed.

Comment

The vinyl windows, which allow visual monitoring of screen operation, get dirty and, therefore, diminish viewing capability. They should be cleaned with a soft cloth, so that the vinyl will not get scratched. Two additional points should be noted. First, larger windows, perhaps $1\frac{1}{2}$ ft \times $1\frac{1}{2}$ ft or more, would be more convenient. Second, the curtain may cut off some of the available light and require installation of additional lighting.

The major advantages of these curtains — long service life, good noise reduction, negligible effect on production, easy care, and ready access to the shakers — indicate that this treatment is one of the commercially available techniques that can work well in the coal preparation environment.

C.7 Clean-Coal Desanding Screens

Two types of treatment were installed on the clean-coal desanding screens located on Level 5. First, because of the critical nature of the screening at this point, curtains were used between the screens and main walkway, rather than resilient screen decks, which had not yet been tested in other areas. Second,

open discharge chutes were lined with abrasion-resistant plastic chute liners. Since the discharging coal shuffles rather than bounces at this location, Minaloy plastic, which had suffered severe wear in the jig refuse chute, was installed for additional testing.

C.7.1 Vinyl curtains

Treatment Description

Approximately 570 sq ft of Singer Partitions 3/4-lb/sq ft lead-vinyl curtains were installed between the shakers and the main walkway in Building B. Figures 55 and 56 show the walkway before and after installation of the movable panel curtains. The cost of the curtain material was approximately \$3.25/sq ft.

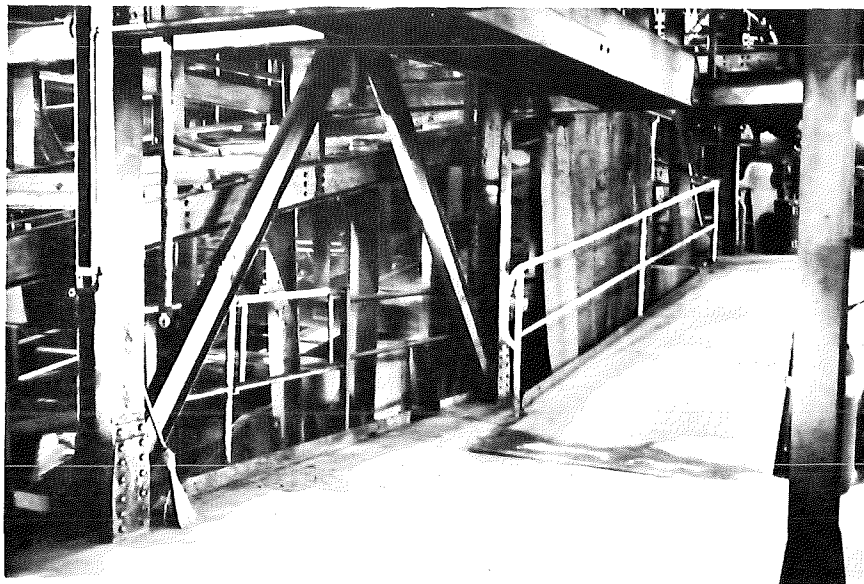


FIG. 55. CLEAN-COAL DESANDING SHAKERS BEFORE CURTAIN INSTALLATION (LOOKING TOWARD RAMP TO BUILDING A).



FIG. 56. CLEAN-COAL DESANDING SHAKER AREA AFTER INSTALLATION OF CURTAINS (LOOKING DOWN RAMP FROM BUILDING A).

Installation

Ninety feet of curtain track were welded to the existing steel I-beams, which ran the length of the shakers. The curtains were hung on standard wheeled rollers. Velcro tape was sewn to the vertical edges of curtain panels to fasten the panels together during normal operation. No observation windows were installed in these curtains. Welding 90 ft of track and hanging the curtain panels required 2 men for 2 shifts.

Service Life and Maintenance

The curtains were installed on 30 September 1976. As of the final inspection on 23 June 1977, the curtains were in good condition. No maintenance had been required.

Performance

The original sound levels alongside the shaker were 96 to 98 dB(A). After the installation of the movable curtain panels, the sound levels alongside the shaker were 93 to 94 dB(A) — a reduction of 3 to 4 dB(A). The limiting factor in the performance of the curtains is the opening over the top of the curtains (visible in Fig. 56), where sound escapes. Stationary curtain panels (sketched in Fig. 57) are planned for installation above the existing movable sections to seal this gap. The expected result is an additional 2 to 3 dB of noise reduction. While these curtains have not noticeably affected the production of these shakers nor interfered with their maintenance, the installation of observation windows in the curtain panels would enhance their acceptability by the workers.

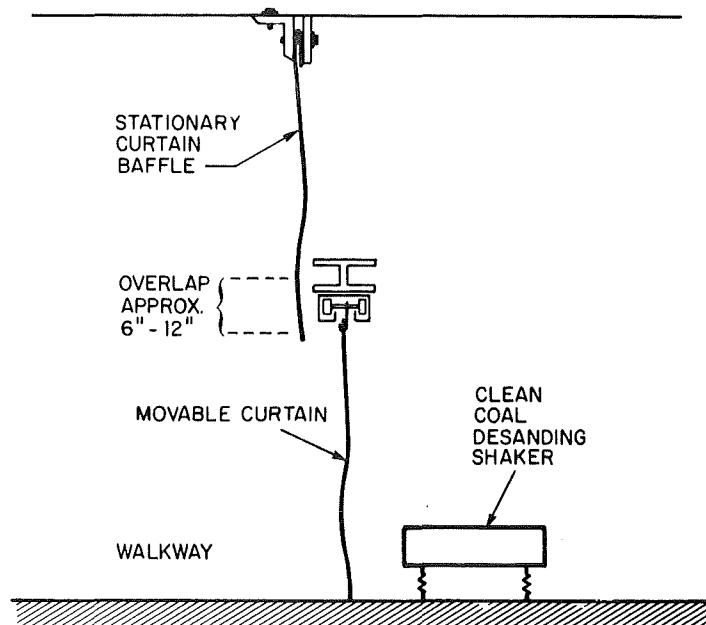


FIG. 57. SKETCH OF FINAL CURTAIN INSTALLATION FOR CLEAN-COAL DESANDING SHAKERS.

Cost

The cost was \$1845 for curtain material, \$540 for hardware, including the Velcro tape, and 4 man-shifts for installation. The stationary panels, scheduled for installation between the top of the existing panels and the ceiling, are expected to cost an additional \$1800 to \$2000.

C.7.2 Minaloy lining for discharge chutes*Treatment Description*

Minaloy plastic chute liner (1/2-in.-thick) was installed in the discharge sections of the clean-coal desanding screens. Connected to the screens are flat, open discharge chutes that oscillate back and forth with the screens. The result is a relatively smooth shuffling of the 1-in. × 1½-in. coal as it moves along the discharge chute. At the end of the chute, the coal drops 4 to 6 ft to receiving hoppers. Figure 58 shows the general configuration for one side, including the areas lined with the Minaloy.

Three sheets (each 4 ft × 10 ft, or a total of 240 sq ft) of 1/2-in. Minaloy were required to line both parts of each of the two discharges.

Installation

The first step in the installation was to weld studs, thread up, to the existing steel chute. The Minaloy was then cut to size and bolted into place. Holes were countersunk to protect the bolts when the Minaloy was bolted into place.

The installation for both shakers was completed by 2 men in 2 shifts.

Service

The material was installed on 22 September 1976. After approximately 2½ months, the Minaloy in the discharge chute area showed ripple-like wear patterns, which did not deteriorate significantly during the rest of the observation period.

Within 5 months after installation, the Minaloy in the bins showed worn patches at the point where the coal impacts the bin wall. A typical worn patch (Fig. 59), measured 2 months later, was approximately 2 to 4 in. wide and 18 in. long.

The steel bin wall typically began to show worn patches after 1 year of use.

Performance

Before installation of the Minaloy liners, the sound level over the discharge section of the clean-coal desanding screens was 96 dB(A). After installation, the sound level was 95 dB(A), a reduction of 1 dB. This small reduction indicates that at this measurement position, the noise radiating directly from the impact of the coal on itself and on the Minaloy liner is more

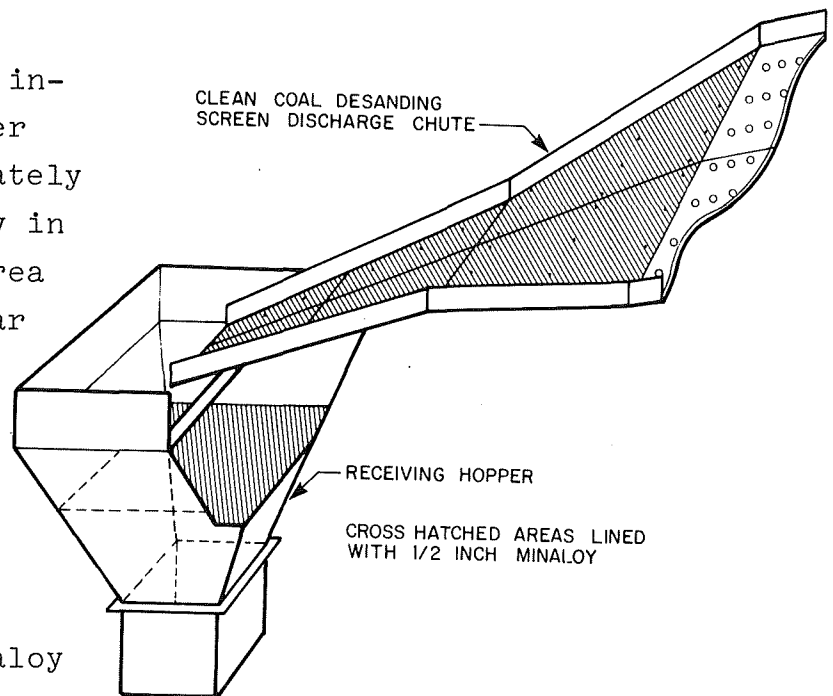


FIG. 58. DISCHARGE SECTION OF CLEAN-COAL DESANDING SHAKER.

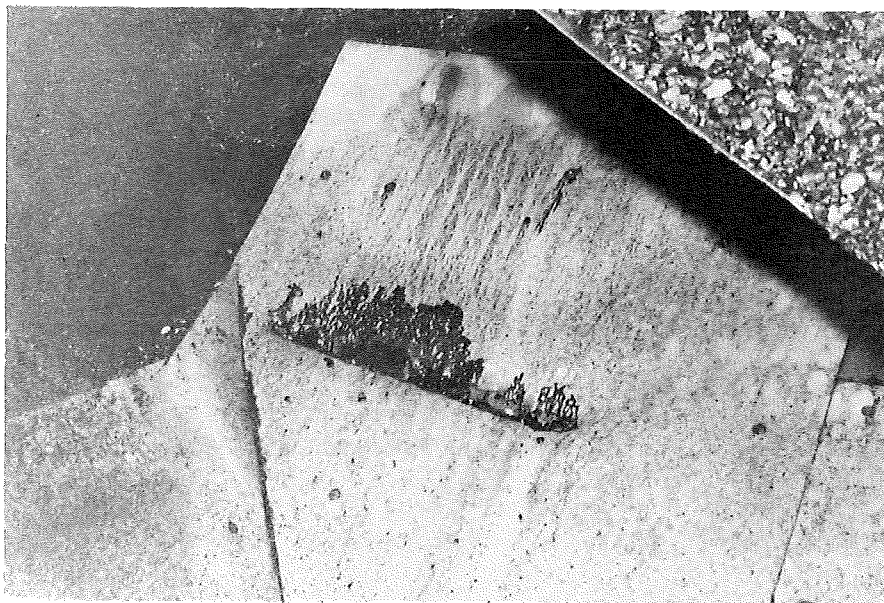


FIG. 59. WORN AREA IN MINALOY BIN LINERS AT DISCHARGE OF CLEAN-COAL DESANDING SHAKERS.

significant than the sound radiated by the vibrating chute walls. The treatment of the discharge sections of the secondary screens, discussed previously, resulted in similar findings. Note, however, that if the workers' normal positions were below the open-top chutes, the relative magnitude of these two source-path mechanisms might change, particularly if chute walls were thin and if there were no sound-reflecting surfaces directly above the open-top chute. The Minaloy did not noticeably affect the efficiency of the screens.

While it is too early to judge the full-service life of the Minaloy lining in the chutes, the Minaloy at the impact point in the hopper required repair after 7 months.

Cost

The entire Minaloy installation cost approximately \$2450. Although the reduction of noise was small, the Minaloy may provide good resistance to wear in the discharge chutes. In the bins, however, the Minaloy proved unsuitable for impact-type wear.

C.8 Ripl-Flo Screen Feed Conveyor

Treatment Description

Singer Partitions lead-vinyl curtains were used as a barrier between the main walkway and the flighted chain conveyor, which feeds the Ripl-Flo screens below. The curtain material has a surface density of $3/4$ lb/sq ft. Roughly 750 sq ft of the material was hung in the standard movable configuration.

Installation

The curtain track was installed on existing I-beam structural supports, and the curtain panels were hung on roller-hooks, with Velcro tape for fastening adjacent panels. Figures 60 and 61 show the area before and after curtain installation.

The entire installation was completed by 2 men in 2 shifts.

Service

The curtains were installed on 15 August 1976. As of the last inspection, all curtain panels and Velcro strips were in good condition.

Performance

The sound levels at position No. 2 beside the conveyor varied between 94 and 96 dB(A). Occasionally, as the conveyor

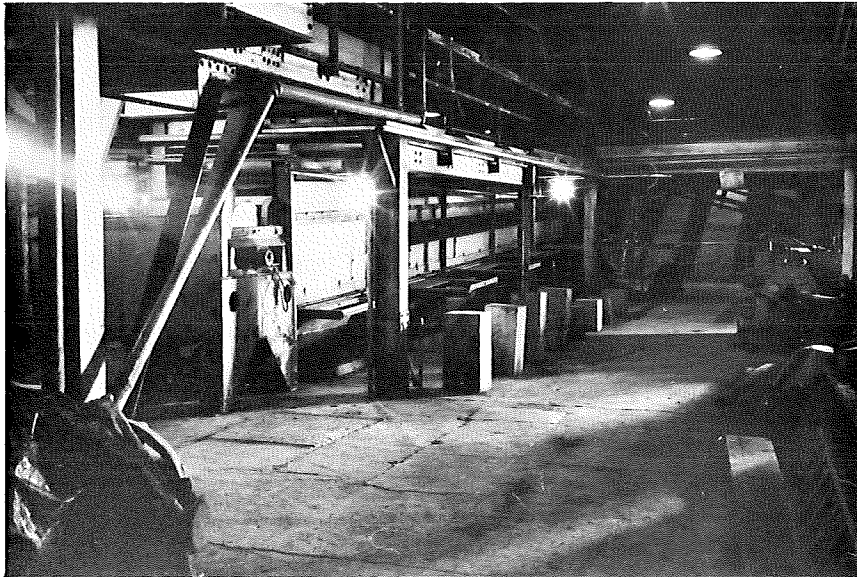


FIG. 60. RIPL-FLO SCREEN FEED CONVEYOR AREA BEFORE CURTAIN INSTALLATION.



FIG. 61. RIPL-FLO SCREEN FEED CONVEYOR AREA AFTER CURTAIN INSTALLATION.

flights rubbed against the conveyor structure, squeaks were measured well in excess of these levels [97 to 99 dB(A)]. After installation of the curtains, the sound levels at position No. 2 were typically 91 to 92 dB(A); they were heavily influenced by the noise of the clean-coal desanding shaker discharges, and somewhat by the sound propagating over the top of the curtain.

Again, the presence of the curtains did not significantly inhibit either production or maintenance of the conveyor.

Cost

The total cost for installation of these curtains was \$3300.

C.9 Grundlach Coal Crushers

Three types of noise control treatment were installed in the Grundlach crusher area (Fig. 62):

- Resilient impact pads - flat urethane pads and ribbed rubber pads

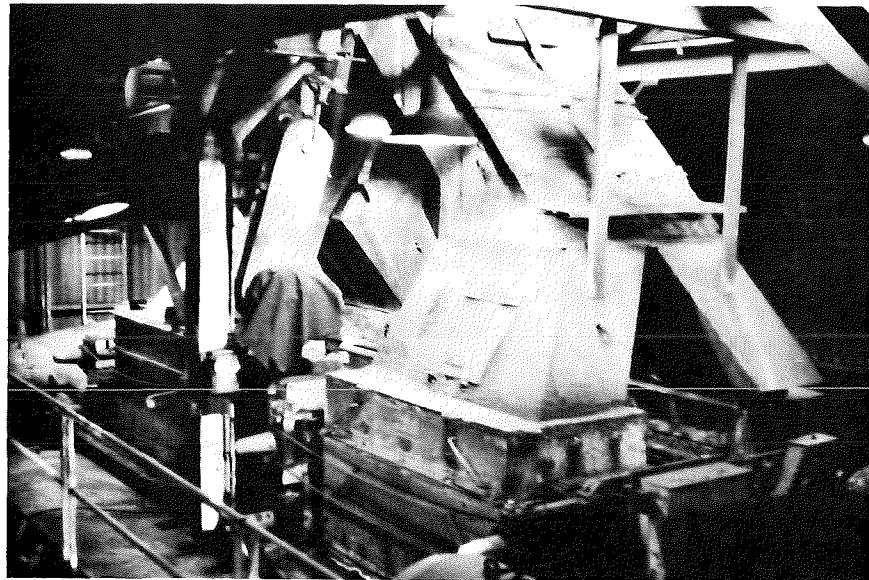


FIG. 62. FOUR GRUNDLACH CLEAN-COAL CRUSHERS.

- Resilient chute liner
- Curtain barrier.

C.9.1 Resilient impact pads

Treatment Description

Two types of resilient impact pads were installed at the head end of the 7 × 1¼ clean-coal belt to absorb the impact of the coal as it comes off the belt and strikes the steel chute wall. The first was a 3-ft × 3-ft pad of 1½-in.-thick urethane, obtained from McBride Industries at a cost of approximately \$300.

This pad was eventually replaced by a 3-ft × 3-ft ribbed rubber pad of 2-3/16-in.-thick profiled Trelleborg-VP, the same material as was used at the McNally jig refuse elevator discharge. Cost of this pad was \$595.

Installation

The flat urethane pad was installed on the vertical chute wall opposite the end of the belt conveyor, where the coal leaving the belt impacts the chute wall. A row of hex-head bolts along the top edge of the pad held it in place. The installation was completed by 2 men in 3 hours; it included some preparation of the steel wall.

The Trelleborg-VP plate, with steel U-channels molded into its rear face, was also bolted to the chute wall with T-bolts. Two men completed the installation of the Trelleborg, which was cut into 2 pieces, in 2 hours.

Service Life and Maintenance

The urethane pad was installed on 17 December 1975. After approximately 8 months of use, a hole had been worn through it at

the impact point (Fig. 63), requiring replacement. The steel plate at the impact point would typically require replacement after 6 months of service.

The urethane was replaced with the Trelleborg pad on 4 September 1976. An inspection on 23 June 1977 revealed that the Trelleborg had been worn through, also at the impact point, and required replacement.

Performance

Although no sound level data were recorded for this installation, the performance of both the Trelleborg and the urethane is expected to be equivalent to the similar installations elsewhere in the plant. Neither pad interfered with the flow of material through the system, and the pad replacement was scheduled and performed during the downshift.

While the flat urethane was replaced with profiled Trelleborg to obtain an impact angle closer to the desirable 90° , there is some question as to whether this was actually achieved. A less-than-optimum impact angle would account for the unexpectedly short service life of the Trelleborg.

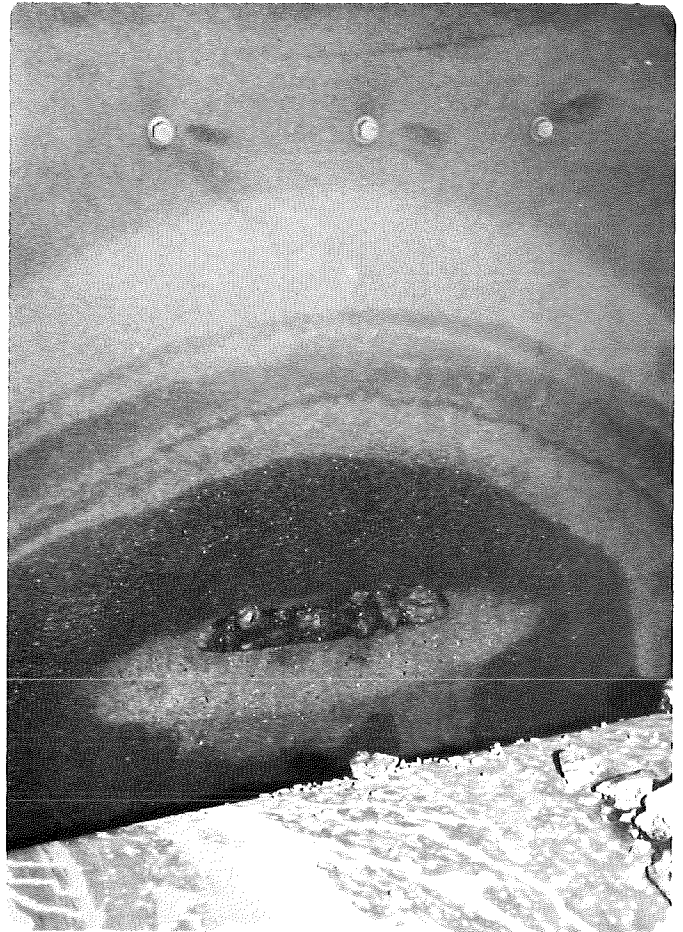


FIG. 63. URETHANE PAD AT HEAD END OF $7 \times 1\frac{1}{4}$ CLEAN-COAL BELT AFTER 8 MONTHS OF USE. NOTE WORN AREA.

The replacement time for the Trelleborg would be comparable to that for the original steel plate.

Cost

On the basis of these single-life cycles, annual costs for the original steel plates, the flat urethane pad, and the profiled Trelleborg pad were \$390, \$510, and \$840, respectively. Note, however, that a refined installation of the Trelleborg pad could extend its surface life and thus reduce annual costs.

Comment

The worn urethane pad that was removed from the chute was still suitable for use in other locations. The pad was cut in half (through the worn area) and installed as an impact pad on the picking table on 6 November 1976. Workers found that the bevel in the material thickness, created as the coal wore through the pad, provided a smooth transition between the top surface of the urethane and the steel picking table.

C.9.3 Resilient chute liner

Treatment Description

Approximately 32 sq ft of Trelleborg rubber (2-3/16-in.-VP plate) was installed in the infeed chutes to the crushers to reduce chute noise. The Trelleborg was 60-durometer and cost \$46 per sq ft.

Installation

The Trelleborg sheet was bolted into place along the bottom of the chute, which had a relatively shallow slope. The installation was completed by 2 men in 1 shift.

Service Life and Maintenance

The Trelleborg pads were installed in the crusher infeed chutes on 5 June 1976. During the next three days, the coal infeed in the chutes backed up to the extent that the lining had to be removed on 8 June 1976.

Performance

The short in-use period of this treatment prevented acoustic tests. Because the treatment was not suitable for this location, no estimate of the acoustic effectiveness was made, nor could full-service life or maintenance requirements be evaluated.

If very shallow slopes are to be lined, flat pads can usually be designed, using slide-angle information obtained from the chute liner supplier. A test panel can also be a valuable step prior to a full installation.

Cost

The material costs for this installation were \$1730, including hardware (primarily bolts).

C.9.4 Vinyl curtain

Treatment Description

Approximately 1350 sq ft of Singer Partition 3/4 lb/sq ft vinyl curtain material was used to enclose the Grundlach crusher platform, separating it from the adjacent plant areas. As in other areas, the curtain panels were prefabricated with grommets and major cutting. In this installation, however, the Velcro was glued to the curtain panels, rather than sewn on. One small clear-vinyl viewing window was installed in the curtain with Velcro strips.

Installation

The installation, which was completed by 2 men in 6 shifts, was very similar to the previously discussed curtain installations in that the curtain track was first mounted (by bolting and welding) to the existing building structure; the curtains were then hung with roller hooks. Openings for chutes were cut in the curtain panels during installation.

Service

The curtains were installed on 15 March 1977. As of the final inspection on 23 June 1977, the curtain panels were generally in good condition, though in some places the glued-on Velcro strips were beginning to peel off. The peeling was sufficient to prevent an effective seal between adjacent curtain panels. The Velcro that held the observation window in place also showed some separation.

Performance

Before installation of the curtain, the sound level in the aisleway adjacent to the crusher platform was 96 dB(A). After installation, this level was reduced to approximately 90 dB(A), a 6-dB(A) reduction.

The curtains have not affected the operation or maintenance of the crushers, particularly since they can be opened for maintenance and service.

The viewing window should be cleaned once every shift or so to remain effective.

Cost

The curtain material cost \$4390 and the hardware costs are estimated to be \$1100 for a total material cost of \$5490. The hardware was primarily composed of those items identified previously for the secondary screen curtain installation.

Since the repair of the Velcro strips has not as yet been undertaken, no costs or time estimates are available.

C.10 Rip1-Flo Screens

Two basic treatments were experimented with on the Rip1-Flo screens:

- Resilient screen decking to reduce the coal/screen impact noise
- Resilient chute liners for the screen discharges.

C.10.1 Resilient screen decks*Treatment Description*

Resilient screen decks were installed on the No. 1 and No. 7 Rip1-Flo screens. The screens, supplied by Laubenstein, were a composite screen with a 1/4-in.-thick, 85-durometer polyurethane top surface, cold-bonded to a 3/16-in. steel plate. The screen was perforated with 1-1/8-in. hexagonal holes (Fig. 64). The screen panels for the two vibrators (one nominally 5 ft × 14 ft, the other, 4 ft × 14 ft) cost \$2860.

Installation

The screens were interchangeable with the existing steel screen decks, and installation time was the same — 2 men for 1 shift.

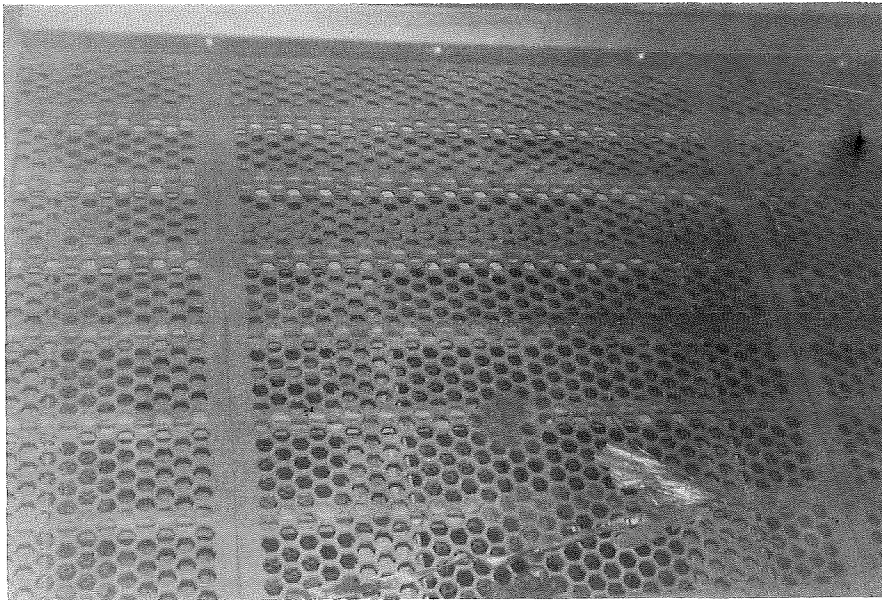


FIG. 64. RESILIENT SCREEN DECK ON RIPL-FLO VIBRATOR.

Service

The resilient screens were installed on unit No. 1 on 8 September 1976 and on unit No. 7 on 17 September 1976.

The No. 1 unit, which normally received the most flow of the 7 units (approximately 90 tph total for all 7), began to show some slight blinding in December 1976. In February 1977, about 4½ months after installation, the polyurethane began to separate from the steel plate and the blinding appeared to increase (Fig. 65), possibly because of the separation, at the infeed end of the No. 1 vibrator. After 7 months of use, the separation of the polyurethane and steel on the first two screen panels was nearly complete, and the resilient layer was held in place only at the edges of the punch plate. Although some of these panels were left in place, 7 months represented the limit of their service life.

In contrast, the screen panels on the No. 7 vibrator were still in good condition at the final inspection date (23 June 1977), probably because of the significantly smaller coal volume this unit handles.

Performance

Since only 2 out of the 7 units were fitted with the resilient decks, overall sound level measurements would not accurately indicate the noise reduction potential of these screens, because the area sound levels would be dominated by the 5 untreated units. Therefore, measurements were made close-in to assess the reduction of coal-screen deck noise. At 6 in. above the resilient screens on the No. 1 unit, the sound level was 98 to 99 dB(A); 6 in. above the steel screens on the No. 2 unit (which was receiving roughly the same flow at the time), the sound level was 105 dB(A). This 6- to 7-dB reduction, which was attributed to the resilient decking, would result in the area sound levels being reduced to the 95-dB(A) residual noise generated by the drive mechanisms, if all the screens were fitted with such resilient decks.

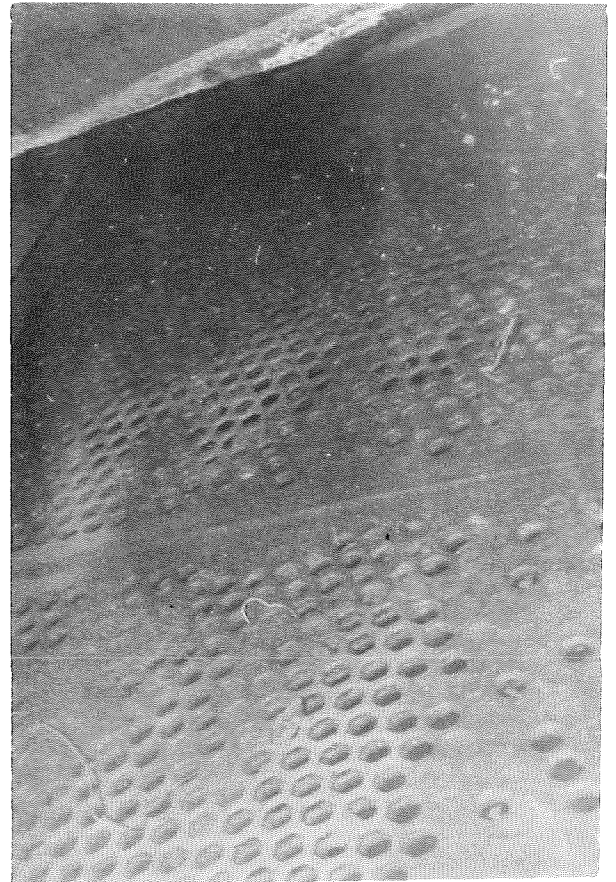


FIG. 65. SEPARATION AND BLINDING OF RESILIENT SCREEN DECKS OF RIPL-FLO VIBRATORS (AFTER 6 MONTHS OF USE).

The usable service life of the screen decks on the No. 1 unit was roughly 47% of the original steel-screen life. Clearly, the separation of the layers represents the major service limitation of this installation.

At this point, maintenance consists of screen replacement.

Cost

The resilient decks cost \$23.50 per sq ft, as opposed to \$6.90 for steel screens. Based on the experience with the screens on the No. 1 vibrator, the cost/ton of the resilient decks was actually closer to 6 times that of the steel screens. It is important to realize, however, that the service life may not in fact be a linear function of product flow, and that the resilient screen on the No. 7 vibrator may not fare so poorly.

Comment

Laubenstein has suggested that the acid in the runoff from the coal may have contributed to the failure of the bond between the urethane and the steel plate. If this problem can be solved, these screens may prove to be an acceptable treatment in such installations, since the blinding (worsened by the separation) was still not nearly as severe as in the other resilient deck applications in the plant.

C.10.2 Resilient lining for discharge chutes

Treatment Description

Two chute lining materials were installed in 4 of the discharge chutes that receive the 1½-in. coal from the Ripl-Flo vibrators (Fig. 66). One material was 1/2-in.-thick Goodyear Armaplate, the same steel-backed rubber that had been used in

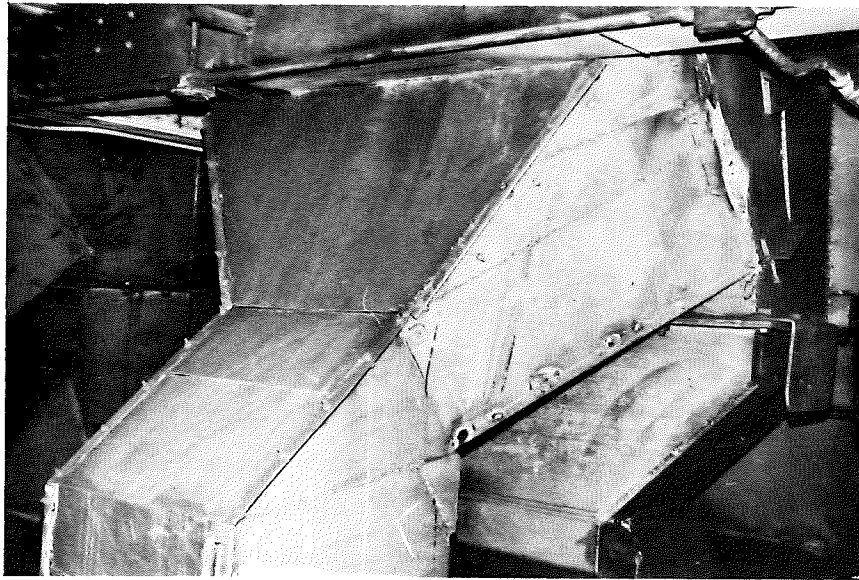


FIG. 66. DISCHARGE CHUTE FROM NO. 3 RIPL-FLO SCREEN (BUILDING B, LEVEL 6).

various other applications in the plant, including the picking table and secondary discharges. The other material was 1/2-in. Goodyear Jade Green Armabond. This 60-durometer rubber, which does not have a steel backing, comes in rolls and can be cut with a sharp knife. Material costs for both the Armaplate and Jade Green were roughly comparable, just under \$6 per sq ft for the 1/2-in. thickness. Fifty square feet of material were required for each chute.

Installation

The Armaplate was cut to size with a power saw and torch, as described earlier, and tack-welded into 2 new steel chutes. Two men worked 2 shifts to complete the installation.

The Goodyear Jade Green Armabond was also installed in 2 new steel chutes. The Jade Green was cut with a knife and glued to the inside chute wall with the adhesive recommended by Goodyear

(Figs. 67 and 68). The interior chute surfaces were cleaned prior to gluing, and the Armabond was clamped to the chute wall until the glue cured. The installation time was approximately half of that required for the Armaplate.

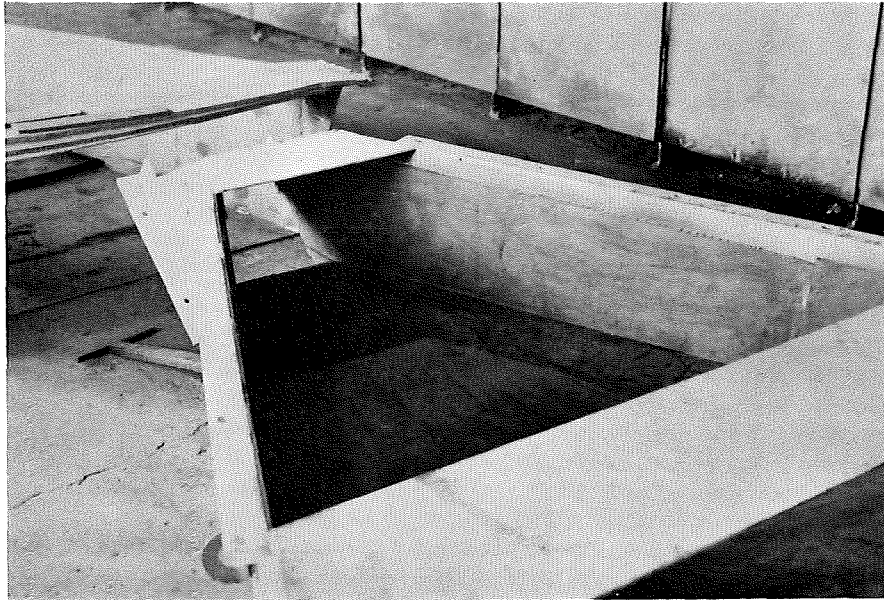


FIG. 67. GOODYEAR ARMABOND GLUED IN UPPER SECTION OF RIPL-FLO DISCHARGE CHUTE.

Service Life and Maintenance

The following table summarizes the installation dates for the four experimental chutes.

Chute No.	Material	Installation Date
3	Armaplate	January 8, 1977
4	Jade Green Armabond	December 18, 1976
5	Armaplate	December 11, 1976
6	Jade Green Armabond	January 22, 1977

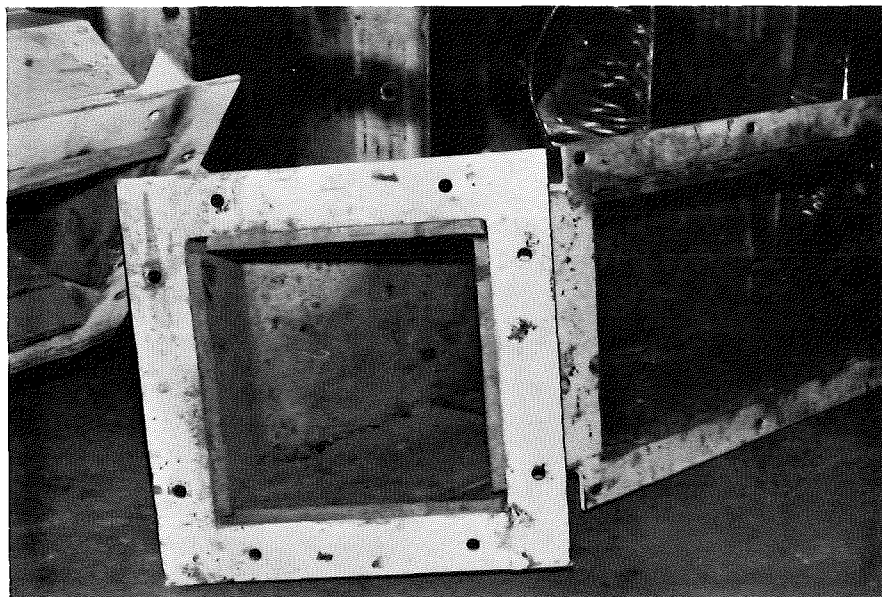


FIG. 68. GOODYEAR ARMABOND INSTALLED IN LOWER SECTION OF RIPL-FLO DISCHARGE CHUTE.

With only one exception, the material allowed smooth product flow. The exception occurred when a piece of wood from the screens lodged in the narrow section of one of the resilient chutes and resulted in some backup of the coal flow. While there is some question as to whether the wood would have passed through a steel chute unimpeded, this should not be a typical problem.

Six months after installation of the Jade Green Armabond in the No. 4 chute, some coal had pushed between the rubber layer and the steel chute wall (Fig. 69). The separation, though small, should be repaired to prevent a major separation of the rubber layer. Care should be taken to protect the edges of the Armabond layers in such installations.

In general, abrasion-related wear has not been significant in these chutes as of the 23 June 1977 inspection date. In

comparison, the original steel chutes began to show such wear after approximately 18 months.

Performance

Acoustic evaluation of the chutes involved close-in measurements to treated and untreated units. Measurements showed that the resilient lining provided a minimum* of 6-dB noise reduction.

There was no significant effect on production other than that discussed under "Service," and it is too early to judge the overall service life of the two materials.

Cost

The difference in total costs (both materials cost approximately \$5.75 per sq ft) for the two linings related to installation effort. The installation of the Jade Green Armabond required 2 men working 3½ hours, while installation of the Armaplate required a full shift. If the Armabond proves to wear as well as the Armaplate, the relative ease of installation would make it the material of choice.

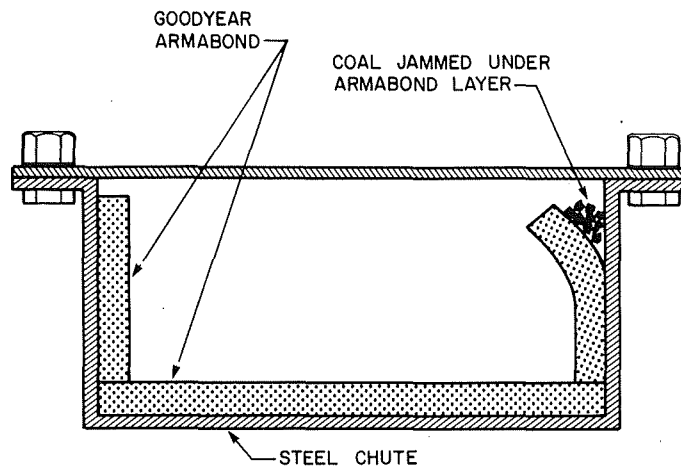


FIG. 69. CHUTE NO. 4 CROSS SECTION, SHOWING LOCATION OF ARMABOND SEPARATION.

*It was not possible to obtain the upper limit of the treatment's effect because of the ambient sound level in the area.

C.11 Cone Refuse Desanding Shaker

This shaker separates the sand from the refuse that comes from the chance cones. Its noise comes from the refuse impacting the screen deck and discharge chute. Only the discharge chute, however, was treated during this project. (Treatment of the screen deck was to be based on resilient screen decks, if they were successful in the other installations.)

Treatment Description

Impact noise is generated at this location when the refuse drops off the end of the desanding screen onto the discharge chute bottom, which has an approximately 15° slope. To reduce the noise, a 30-in. × 132-in. piece of 1-in.-thick urethane was installed in the chute bottom. The cost for this material was \$605.

Installation

Two men installed the urethane in 3 hours. Installation involved bolting the material to the existing steel chute bottoms (Fig. 70) and welding steel wear plates to the chute walls to protect the edges of the urethane. (See "Service" under Ripl-Flo chutes for discussion of potential problems.)

Service Life and Maintenance

The urethane sheet was installed on 8 December 1975, and, as of 23 June 1977, was still in service. No maintenance had been performed during this period, and the material did not show any badly worn areas.

Performance

Sound level measurements made at the discharge end of the shaker indicate that the sound level at this position was reduced from 97 dB(A) to 95 dB(A). It is believed that the pad actually reduces the discharge noise more than the 2-dB measured reduction indicates, because the final sound level was controlled by the refuse/screen deck noise, which was not treated.

As of the final inspection, the urethane pad had been in service over 18 months. In comparison, the original steel chute typically required repair after 6 months of service.

There has been no effect on the operations of the system as a result of this installation.

Cost

While it is too early to determine the full-service life of this installation, it has outlasted the original steel chute by a significant margin.



FIG. 70. URETHANE IMPACT PAD IN REFUSE DESANDING SHAKER DISCHARGE CHUTE.

C.12 Reineveld Centrifugal Dryers

Treatment Description

Singer Partitions 3/4-lb/sq-ft lead-vinyl curtains were installed around each Reineveld dryer to reduce the area noise levels and the noise levels to which workers are exposed when working on an individual machine with the adjacent units operating. The 4100 sq ft of curtain material installed in this area cost \$3.22 per sq ft.

Installation

The movable curtain panels, precut and fitted with grommets by the supplier, were hung from the track and roller-hook setup described previously. The curtain track was installed on a steel U-channel that was positioned above the existing overhead hoist track (Fig. 71), used when the dryer covers are removed for basket replacement. The curtains parted at the point where the hoist track passes through the curtain wall, thus permitting dryer maintenance with a minimum of interference. Velco strips, sewn to the curtains, fastened the curtains during normal operation.

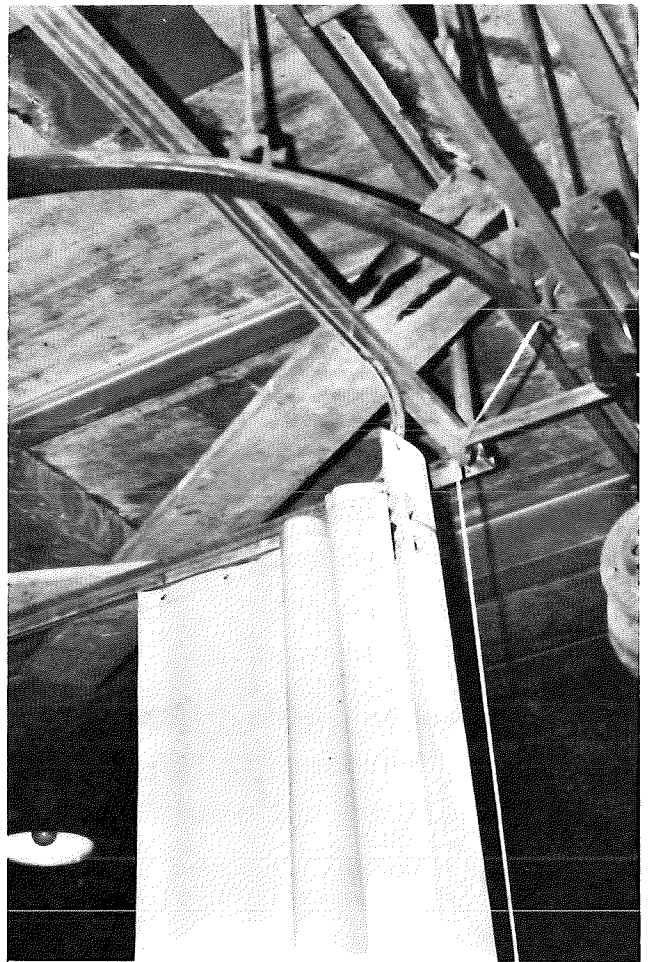


FIG. 71. INSTALLATION OF CURTAINS AND TRACK IN REINEVELD DRYER AREA (NOTE CURTAIN TRACK INSTALLED ABOVE OVERHEAD HOIST TRACK TO AVOID INTERFERENCE WITH DRYER MAINTENANCE.)

Figure 72 shows a completed installation for one of the dryers. Note how the track (15 ft. above the floor) encircles the individual dryer (the curtain panels between adjacent dryers were cut to allow for piping) and how the hoist track passes through the curtain wall. Also visible in Fig. 72 is the stationary curtain baffle, mounted from the ceiling, to reduce the noise that would escape through the opening between the top of the movable sections and the ceiling. The overlap between the movable and stationary panels is about 8 in. Figures 73 and 74 show the Reineveld area before and after the installation of the curtains.

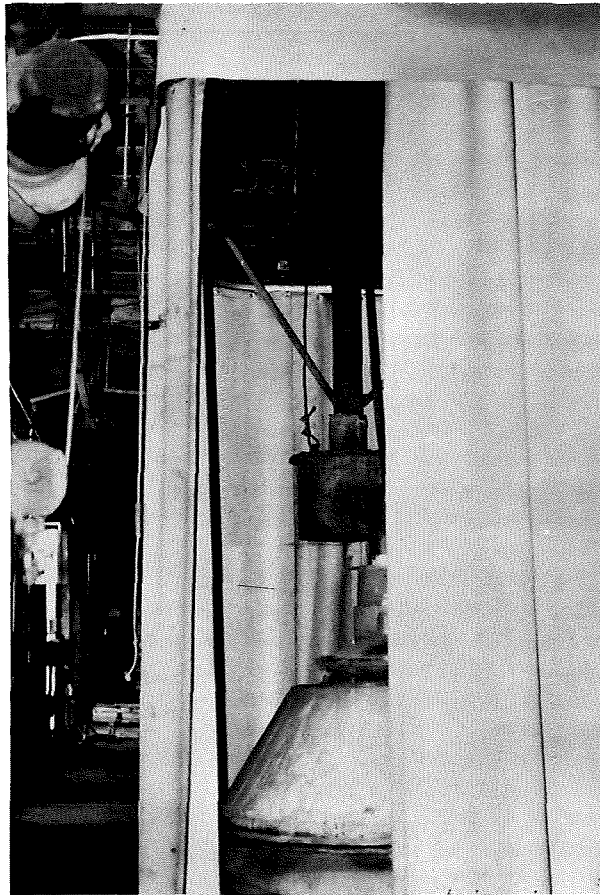


FIG. 72. CURTAIN INSTALLATION AROUND SINGLE REINEVELD DRYER.

Complete installation required 2 men working 20 shifts.

Service Life and Maintenance

The curtains were completed on 15 November 1976, and as of the final inspection on 23 June 1977, they were still in good condition. The Velcro, which was sewn on, operated successfully throughout the observation period.

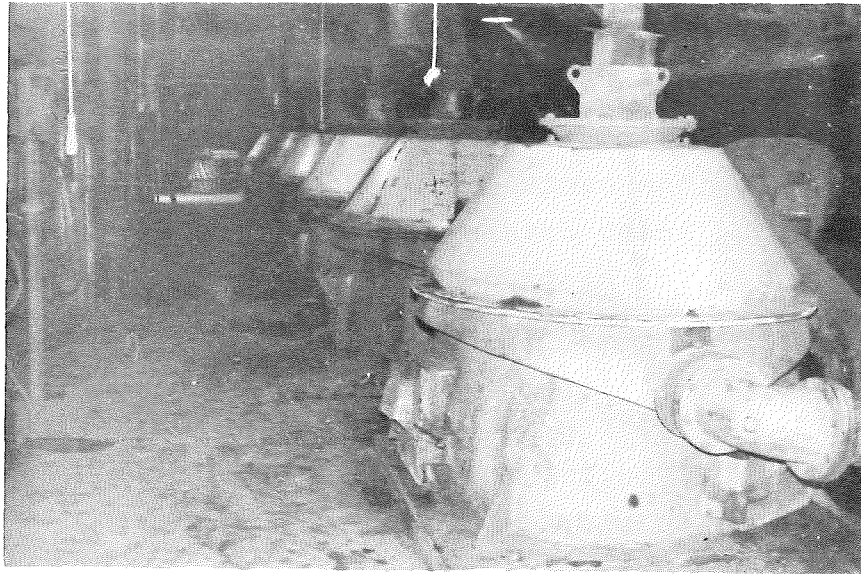


FIG. 73. REINEVELD DRYER AREA PRIOR TO INSTALLATION OF CURTAINS.



FIG. 74. REINEVELD DRYER AREA AFTER INSTALLATION OF CURTAINS.

Performance

The original sound levels alongside the end dryer (Positions M1, M2) were 97 to 103 dB(A). After the installation of the curtain, the sound levels were 89 to 92 dB(A). The effective noise reduction provided by these curtains was 8 to 11 dB(A).

Because these curtains do not contain any sound-absorbing material, there was some sound buildup inside the curtains. Figure 75 shows the sound pressure level spectra measured inside and outside the curtains for the end dryer. Although the other dryers contribute to some extent, it is possible to see the effect of sound buildup in this figure.

The curtains have not affected either the production or maintenance on these units.

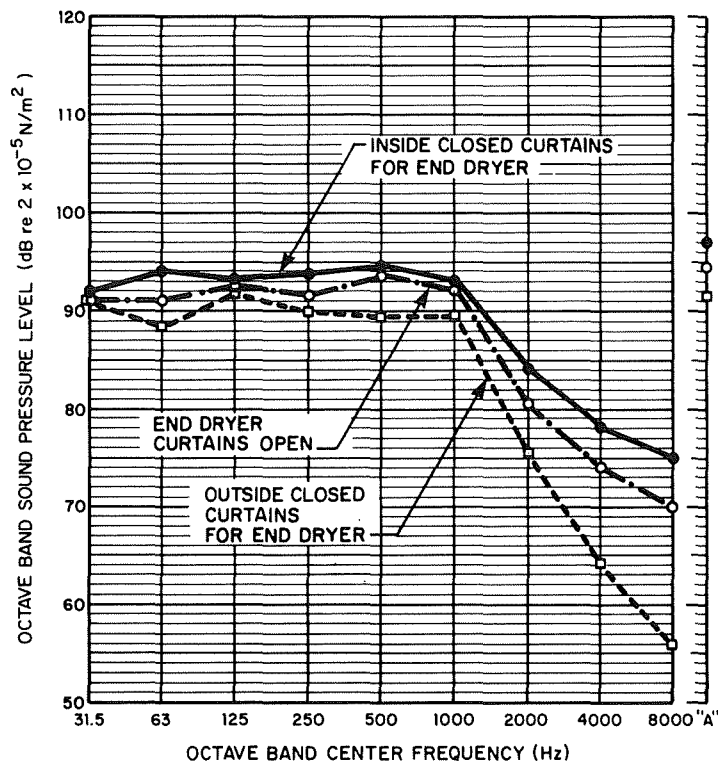


FIG. 75. SOUND PRESSURE LEVELS MEASURED AT REINEVELD DRYER CURTAINS.

Cost

The material costs were \$13,255 for curtain material and \$2700 for hardware, including track, roller hooks, channel, and mounting and connecting brackets.

C.13 Wemco Dryers*Treatment Description*

To reduce the impact of the Wemco dryer noise on the surrounding plant areas (such as the Deister table area), curtains were installed on three sides of the Wemco dryer area. The vinyl curtain material was the same as that used for the Reineveld dryer area (i.e., Singer Partitions, 3/4-lb-per-sq-ft lead vinyl). The complete installation required 1100 sq ft of curtain material at a cost of \$3.22 per sq ft.

Installation

The curtain track was mounted to the existing building structure from which the prefabricated curtain panels were hung using the roller hooks. Stationary ceiling baffles, similar to those between the ceiling and curtain track on the Reinevelts, were also installed. The entire installation was completed by 2 men in 3½ shifts.

Service Life and Maintenance

The curtains were completed on 7 April 1975, and, as of 23 June 1977, were still in good condition.

Performance

Figure 76 shows the effectiveness of the curtains, as well as the magnitude of the sound buildup within the curtains. No

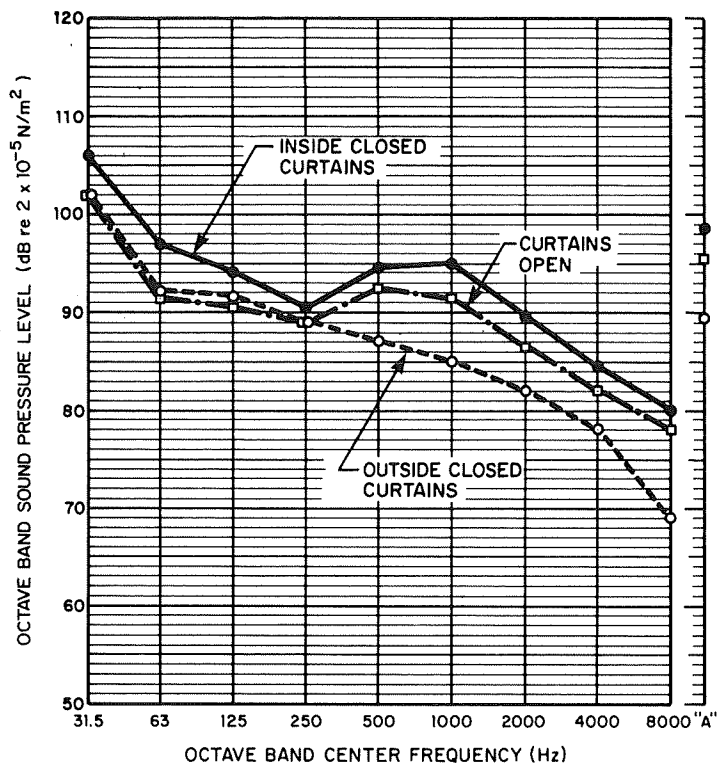


FIG. 76. SOUND PRESSURE LEVELS MEASURED AT WEMCO DRYER CURTAINS.

acoustically absorptive material was used in this installation. The overall noise reduction from original to final sound levels in the aisle adjacent to the dryers was 6 dB(A).

No operational or maintenance problems have been encountered as a result of this installation.

Cost

The total material cost was \$3500 for curtains and \$690 for hardware.

C.14 Classifying Shakers

Two types of treatments were installed in the classifying shaker system:

- Resilient impact pad
- Resilient screen decks and Minaloy pan liner.

C.14.1 Resilient impact pad

Treatment Description

An 18-in. × 54-in. piece of 2-3/16-in. profiled Trelleborg-VP was installed in the feed chute to the classifying shaker to absorb the impact generated by the coal coming off the crushed coal belt (from the Grundlach crushers) and striking the vertical chute wall. The Trelleborg pad cost \$290.

Installation

Installation was relatively straightforward because the location was within a couple of feet of the readily accessible open top of the chute (Fig. 77). The pad was bolted in with T-bolts in the usual manner (see discussion of picking table). Two men worked 2 hours to complete the installation.

Service

The pad was installed on 9 September 1976. As of the last inspection on 23 June 1977, the Trelleborg was still in good condition, showing only a slight rounding of the edges.

No maintenance was required or performed on this pad.



FIG. 77. PROFILED TRELLEBORG INSTALLED AT HEAD END OF CRUSHED COAL BELT (INFEEED TO CLASSIFYING SHAKERS).

Performance

Prior to installation of this pad, the sound level at this chute (position Q_1) was 100 dB(A). Although the noise of the classifying shaker also contributed to this sound level, the impact of the coal on the chute wall was the major noise source. After the installation of the Trelleborg and the resilient decking on the screen, the sound level at position Q_1 was 91 to 94 dB(A).

No effect on the operation of the system was noted as a result of the pad. As of the last inspection, the pad had been in service for over 9 months. This compares well with the typical 6-month life of the original steel chute wall.

Cost

The material cost was \$290 for the Trelleborg and an estimated \$25 for mounting bolts. In comparison, the original steel plate cost \$25. The installation times for the two were 4 man-hours.

C.14.2 Resilient screen decks

Treatment Description

The remainder of the treatments on the classifying shaker are summarized in Fig. 78. The major components, the resilient

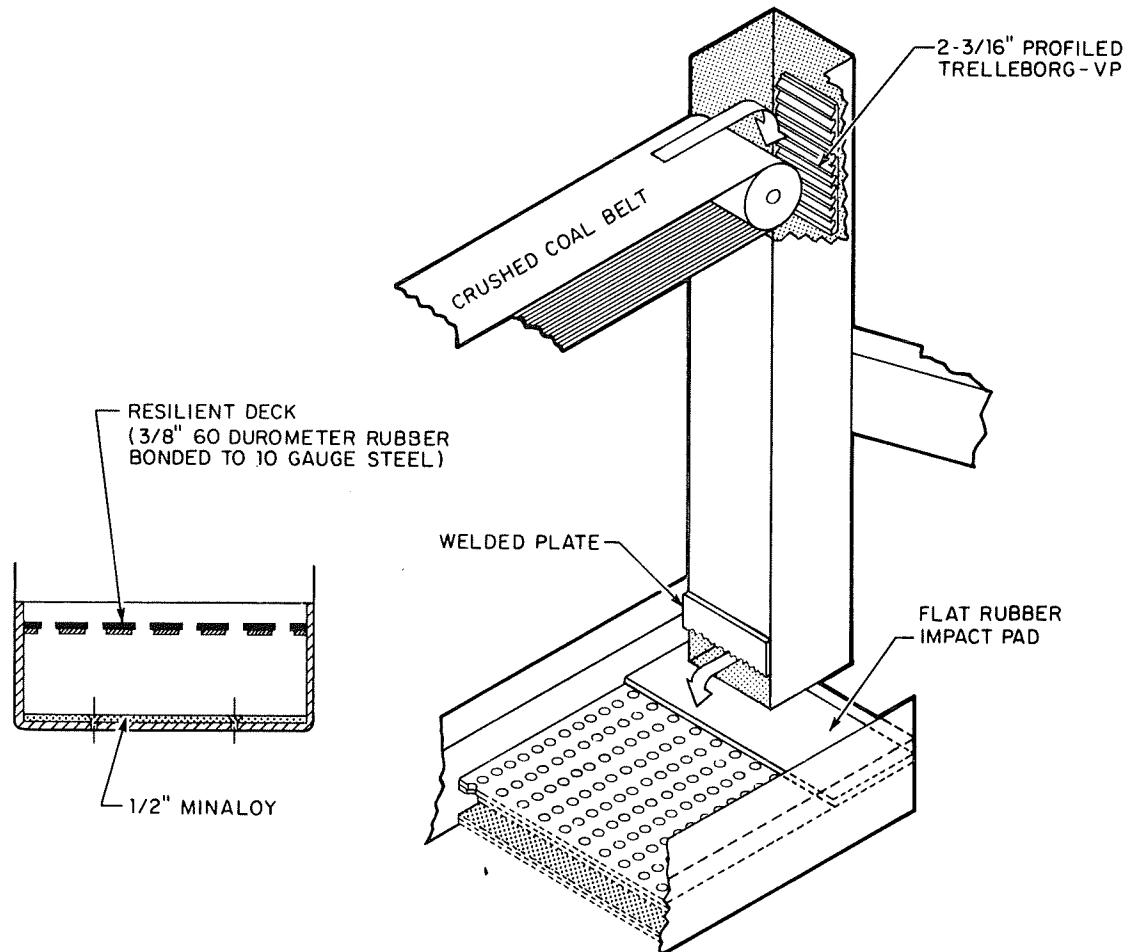


FIG. 78. CLASSIFYING SCREEN NOISE CONTROL TREATMENTS

decking, was a composite deck, with a top layer of 3/8-in. 60-durometer rubber bonded to a 10-gauge steel support plate. The diameter of the holes in the steel was $1\frac{3}{4}$ -in. vs $1\frac{1}{2}$ -in. for the rubber layer, to minimize an expected blinding problem. The resilient decks cost \$3650.

The bottom pan of the shaker was lined with 1/2-in. Minaloy to reduce some of the noise radiation from the bottom pan to the floor below. Approximately 280 sq ft of Minaloy were used at a cost of \$2500.

A piece of solid flat rubber was also installed at the head end of the shaker to absorb the impact and to protect the leading edge of the screens (Fig. 79).

Installation

Two men worked $5\frac{1}{2}$ shifts to complete the installation, which involved bolting the Minaloy into place as was done in the clean-

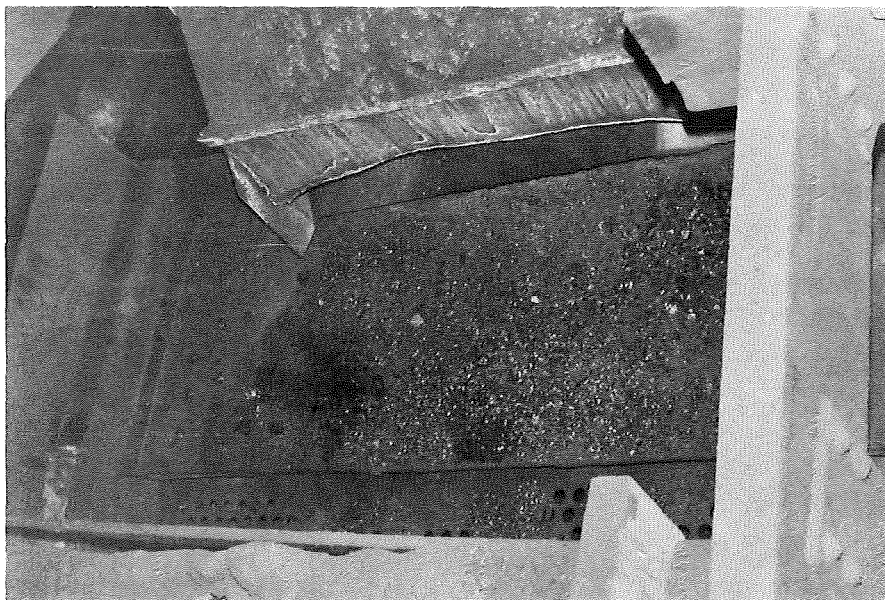


FIG. 79. FLAT RUBBER IMPACT PAD AT INFEEED END OF CLASSIFYING SHAKER.

coal desanding shaker discharges, replacing the original steel screens with resilient decks (with some adjustments of the mounting brackets), and installation of the impact pad at the infeed end.

Service Life and Maintenance

The installation was completed on 8 December 1976. Within the first several months of use (shakers are used an average of only 2 days a week), blinding became a significant problem. For the screens to operate effectively, it became necessary to unplug the blinded holes (as many as 60 to 70%) by hand at the end of each shift.

Six months after the installation was completed, maintenance personnel reported that some parts of the rubber and steel layers were beginning to separate.

Performance

Figure 80 shows the sound pressure level spectrum measured close-in (12 in. above) to one of the remaining steel screens and one of the resilient decks. The overall difference is 8 to 9 dB(A). Alongside the shakers (position Q_2), the sound level was reduced from 102 dB(A) to 97 to 98 dB(A), a 4- to 5-dB(A) reduction.

While it is too soon to judge the total service life of this installation, blinding is by far the major limitation.

Cost

The resilient decks used on the classifying shaker cost \$16.50 per sq ft vs \$6.10 per sq ft for the original steel decks. The Minaloy cost \$8.95 per sq ft, or a total of \$2505.

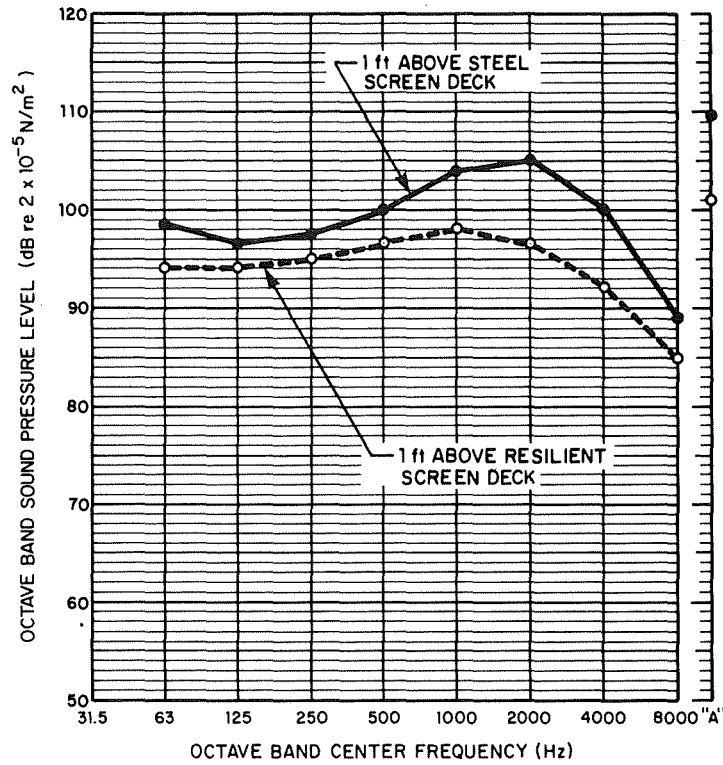


FIG. 80. COMPARISON OF SPLs MEASURED OVER STEEL AND RESILIENT SCREEN DECKS.

Comment

Although this installation did provide some noise reduction for the adjacent aisleways, blinding was a severe operational problem.

APPENDIX D: MATERIALS USED IN NOISE CONTROL TREATMENT

The following is a list of the materials used for noise control treatments in the Georgetown Plant. The list is divided into the four categories of treatments used in the plant and includes the manufacturers' names and addresses (if available), as well as the installation location.

TABLE 11. MATERIAL SUPPLIERS FOR TREATMENTS USED IN GEORGETOWN PREPARATION PLANT.

Treatment Category	Material or Brand Name	Manufacturer/Supplier	Installation or Use in Plant
Resilient Screen Decks	Tuffgard-clad screens	Laubenstein Mfg. Co. (Perforator) Ashland, PA 17921 Hewitt-Robins (Bonding) Conveyor Equipment Div. Passaic, NJ	Secondary Shakers Ripl-Flo Shakers
	Rubber-clad screens	Hendrick Mfg. Co. (Perforator) Carbondale, PA 18407 Gates Rubber Co. (Bonding) Denver, CO 80217	Secondary Shakers
	Rubber-covered screens	Laubenstein Mfg. Co. (Perforator) Ashland, PA 17921 Linatex Corporation* (Bonding) Stafford Springs, CT 06076	Classifying Shakers
	Trelleborg screens	Trelleborg Rubber Co. Mining Services Division 30700 Solon Industrial Pkwy Solon, OH 44139	Secondary Shakers
	Urethane screens	McBride Industries (Supplier) St. Albans, WVA	Secondary Screens
Resilient Impact Pads	Armplate	Goodyear Tire & Rubber Co. Industrial Products Division Akron, OH 44311	Picking Table Middlings Vibrators
	Profiled Trelleborg (Type VP)	Trelleborg Rubber Co. Mining Services Division 30700 Solon Industrial Pkwy Solon, OH 44139	McLanahan Crusher Crop Chute McNally Jigs Clean Coal Belt Grundlach Crushers Crushed Coal Belt
	Urethane	McBride Industries (Supplier) St. Albans, WVA	Picking Table McNally Jigs Clean Coal Belt Refuse Desanding Shaker
Chute Liners	Armplate & Armabond	Goodyear Tire & Rubber Co. Industrial Products Division Akron, OH 44311	Ripl-Flo Discharges
	Durafrax Alumina Ceramic Tile	The Carborundum Co. Refractories & Insulation Div. Box 367 Niagara Falls, NY 14302	McNally Jig Refuse Chutes
	Minaloy Ultra High Molecular Weight Plastic	Workman Developments (Supplier) 1741 Woodvale Rd Charleston, WVA 25314	McNally Jig Refuse Chutes Clean Coal De-sanding Shakers Classifying Shakers
Vinyl Curtains	Sound Stopper Curtains	Singer Partitions 444 North Lake Shore Dr. Chicago, IL 60611	Secondary Screens Clean Coal De-sanding Screens Screen Feed Conveyor Grundlach Crushers Wemco Dryers Reineveld Dryers
	Dura-Sonic Curtains	Duracote Corp. 350 North Diamond St. Ravenna, OH 44266	Middlings Vibrators

*Linatex screens are also available through Hendrick Mfg. Co. and from Linatex directly.