NOISE CONTROL IN COAL PREPARATION PLANTS

By Thomas G. Bobick[1] and Matthew N. Rubin[2]

ABSTRACT

This paper presents the results of two recent Bureau of Mines sponsored programs related to noise control in coal preparation plants. These programs were aimed at evaluating engineering controls for reducing the occupational noise exposure of plant workers. The first of these two programs evaluated the performance of various noise control techniques in an operating preparation plant. Four general categories of noise control treatments were selected, installed, and monitored over an extended period of time to evaluate their acoustic performance and durability. The four categories were resilient screen decks, resilient impact pads, chute liners, and mass-loaded curtains. This program demonstrated that the treatments can be both effective (providing 5 to 10 dBA of noise reduction) and durable (with effective service lives of 1 to 4 yr).

The second project focused on documenting noise control treatments that can be incorporated into new coal preparation plants at the design stage. While some of the treatments considered were similar to those evaluated in the previous project, a number of additional techniques were also considered, such as equipment substitutions and changes in plant layout. Consideration of these techniques is possible for new plants because of the design flexibility provided during the planning stage of a new facility.

INTRODUCTION

The noise levels inside typical coal preparation plants often exceed 90 dBA, and occasionally exceed 100 dBA.[3] Because preparation plant personnel can be exposed to these levels for appreciable portions of their work shifts, the noise exposures of these workers can often exceed those permitted by current Federal noise regulations.[4] Recognizing the potential risk to the hearing of preparation plant workers, the Bureau has sponsored research into noise control techniques for coal preparation plants.

Much of the Bureau's early research has been directed toward noise control for existing plants, concentrating on identifying the major problems and evaluating retrofitable noise control treatments (such as resilient screen decks, impact pads, chute liners, and noise control curtains). This initial work produced a large amount of practical information on a variety of noise control treatments that can assist preparation plant operators in reducing the noise levels in existing plants.[5]

---

[1]Mining engineer, Pittsburgh Research Center, Bureau of Mines, Pittsburgh, PA.
[2]Senior engineer, Bolt Beranek and Newman Inc., Cambridge, MA.
[3]Ungar, E. E., G. E. Fax, W. N. Patterson, and H. L. Fox. Coal Cleaning Plant Noise and Its Control (contract H0133027, Bolt Beranek & Newman Inc.). BuMines OFR 44-74, 1974, 99 pp.; NTIS PB 235 852/AS.
[4]U.S. Congress. Federal Mine Safety and Health Amendments Act of 1977. Public Law 95-164, 91 Stat. 1317-1319.
[5]Rubin, M. N. Demonstrating the Noise Control of a Coal Preparation Plant. Volume I. Initial Installation and Treatment Evaluation (contract H0155155, Bolt Beranak & Newman Inc.). BuMines OFR 104-79, 1977, 182 pp.; NTIS PB 299 963.
______. Demonstrating the Noise Control of a Coal Preparation Plant. Volume II: Long Term Treatment Evaluation (contract H0155155, Bolt Beranek & Newman Inc.). BuMines OFR 143-83, 1982, 91 pp.; NTIS PB 83-237354.

More recently, the Bureau has investigated noise control techniques for new coal preparation plants.[6] New plants often require a different noise control approach than do existing plants, because of advances in plant design; also more flexibility exists for equipment selection and layout during the design stage.

NOISE CONTROL FOR EXISTING FACILITIES

This project (contract H0155155) examined the benefits and limitations of a variety of noise control treatments and materials through in-plant tests. Although such tests do not permit the same degree of control and documentation as laboratory tests, it was felt that data obtained from actual use in commercially operating preparation plants would be more realistic, and thus more useful to the industry.

PLANT DESCRIPTION

The plant selected for this demonstration project was the Consolidation Coal Co. Georgetown preparation plant.

The Georgetown preparation plant was built in 1951 and was designed to process 1,650 tons of raw coal per hour. Although the plant was originally designed to clean both surface and underground coal, there was a distinct shift toward surface-mined coal during the course of this project.

The plant was designed with three basic cleaning circuits: 1-1/2 by 7 in, 3/8 by 1-1/2 in, and 0 by 3/8 in. As shown in figure 1, the raw coal entering the plant is first fed to a primary shaker screen where the oversized material is scalped off and crushed. The secondary sizing screens then separate the flow into the three size classifications. The large material from the top deck of the secondary screens is cleaned in two McNally-Baum[7] jigs, and then sized and/or crushed before loadout. The middle size cut from the secondary screens is cleaned in two Chance sand flotation cones. The clean coal is then dewatered and sized on two clean coal desanding shakers and either sent to Wemco centrifuges for drying (for the smaller material) or loaded out directly (for the larger material). The fine coal from the secondary screens is cleaned on Deister tables and dried in Reineveld centrifuges before loadout.

NOISE CONTROL STRATEGY

The basic noise control strategy was to balance the need for operational data on a variety of commercially available materials with the desire to provide a measure of noise reduction in the demonstration plant. After the demonstration plant was selected, a noise and operational survey was conducted to (1) identify the major noise sources within the plant, (2) determine the noise exposures of plant personnel, and (3) obtain operational data on maintenance, access, and visual-monitoring requirements. Because the selection of equipment to be treated was based on worker exposure, as well as the need for performance data on a variety of commercially available noise control materials, plant areas were categorized as either type I (continuous), type II (partial), or type III (limited) according to the exposure time of plant personnel.

Those pieces of equipment located in type I or II areas and having high sound levels were considered high priority sources in the selection of equipment for

[6] Rubin, M. N., A. R. Thompson, R. K. Cleworth, and R. F. Olson. Noise Control Techniques for the Design of Coal Preparation Plants (contract J0100018, Roberts & Schaefer Co. and Bolt Beranek & Newman Inc.). BuMines OFR 42-84, 1982, 135 pp.; NTIS PB 84-166180.

[7] Reference to specific brand names does not imply endorsement by the Bureau of Mines.

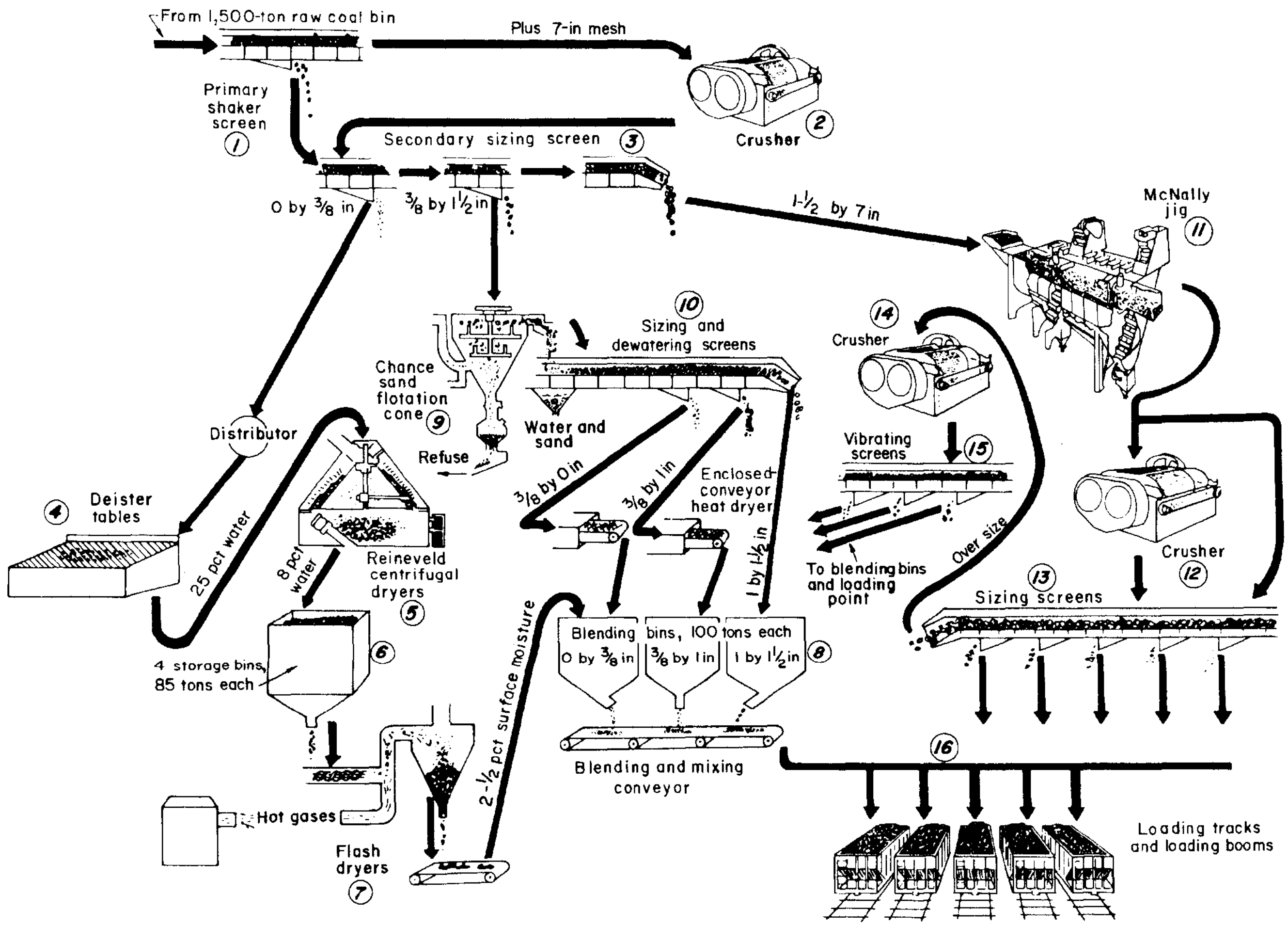

FIGURE 1. - Flow chart of Georgetown preparation plant.

treatment. In general, this program concentrated on treatments for screens, chutes, and dryers.

NOISE CONTROL TREATMENTS

The majority of the noise control treatments selected for use in the demonstration plant fall into the following four categories:

1. Resilient screen decks.
2. Resilient impact pads.
3. Chute liners.
4. Mass-loaded vinyl curtains.

Vibrating screens are probably the largest and most difficult to control noise source in coal preparation plants in general, and in this demonstration plant in particular. For the older, low-speed, crank-arm shakers, the primary noise generating mechanism is the impact of the material flow on the metal screen deck. In modern, high-speed, eccentric-weight screens, the noise generated by the drive mechanism can also be a major contributor.

A number of manufacturers produce screen decks with a resilient (elastomeric) top surface that is intended to reduce the impact noise generated by the material flowing over the deck. To evaluate this feature, a variety of resilient screen decks were selected for testing. Because a redesign of the screen's drive mechanism was beyond the scope of this retrofit project, resilient screen decking was the primary screen modification investigated.

Although the initial tests in the Georgetown plant verified that these resilient decks were capable of reducing the coal-screen impact noise (fig. 2), several operational problems were also identified. These were blinding (particularly for the thicker decks on the crank-arm shakers), and delamination of the resilient top surface of the elastomer-clad steel decks. To determine if these operational problems were common to other plants, and if the newer resilient decks (which had come on the market during the monitoring period) had improved over those initially tested, supplementary screen deck tests were conducted in four other preparation plants.

These supplementary screen deck tests were performed in conjunction with Hendrick Mfg. Co. and Laubenstein Mfg. Co., two of the major screen manufacturers in the United States. Each company made arrangements for testing with two coal preparation plant operators, provided the screen decks to be tested, and arranged for one of its representatives to supervise the installation and monitor the performance of the test decks.

Each screen manufacturer provided representative samples of the two most common types of elastomer-clad decks produced at the time. For Hendrick, these included: (a) a 48-durometer Gates SBR rubber that was vulcanized to steel punch plate, and (b) a 40-durometer Linatex natural rubber cold-bonded to the steel base plate. Laubenstein's decks were manufactured from an 80-durometer Tuffgard polyurethane that was cast onto a steel punch plate, and a 40-durometer Linatex natural rubber cold-bonded to a steel punch plate.

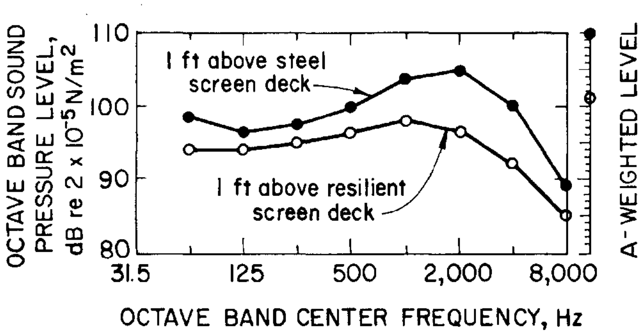

FIGURE 2. - Sound pressure levels measured over steel and resilient screen decks.

In these supplementary screen deck tests, blinding was not found to be a significant factor in any of the four plants in which the tests were performed, and delamination was evident in only one of the four preparation plants. Although the service life of the screen decks varied significantly from one plant to the next, the urethane-cast-to-steel decks proved to be particularly durable, providing almost 2 yr of service in one plant and 1.5 yr in another. In fact, in the latter plant, the panels screened more than 1.5 million tons of coal, and lasted approximately five times longer than the original steel decks (fig. 3). The panels were eventually removed because of cracks in the steel backing rather than wear of the urethane coating.

Resilient impact pads were installed in the Georgetown demonstration plant at the discharge of various belts, basket elevators, screens, and chutes to reduce the noise generated when the material flow impacted the steel chute walls (fig. 4). The impact pads selected were primarily rubber or polyurethane compounds. Both flat and profiled (i.e., ribbed) configurations were used, depending upon the impact angle.

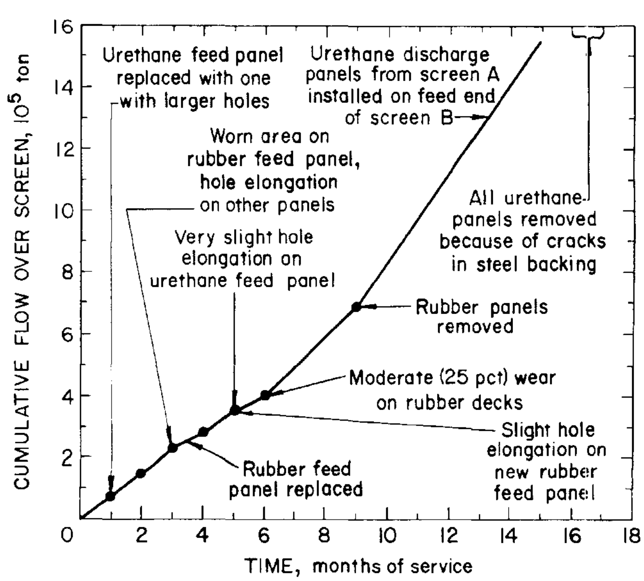

FIGURE 3. - Service history of test decks in plant D.

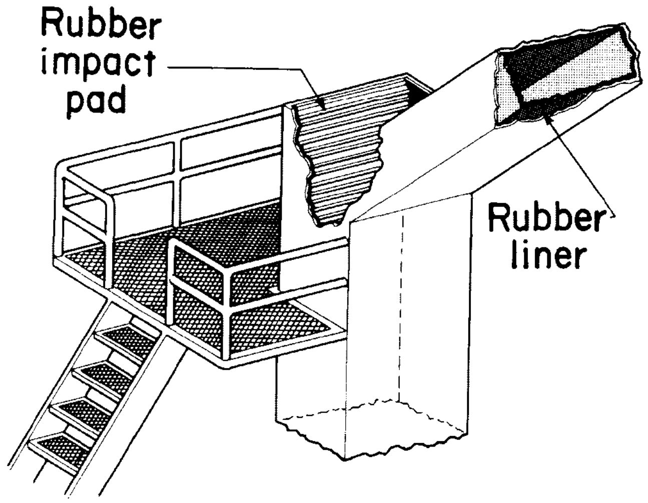

FIGURE 4. - Impact pad and chute liner installations.

Experience at this demonstration plant indicated that these pads were not only effective in reducing the noise resulting from the impact of the material flow, but they could also be a cost-effective solution. That is, when designed and installed properly, the service life of these impact pads can sufficiently exceed that of the original steel plates, which would compensate for their higher initial cost. These tests also confirmed that impact angle and pad thickness are the primary design parameters that must be carefully chosen to achieve maximum performance from the pads.

Because the noise generated by the continual impact of material flow on steel chute walls is a major noise problem in many plants, including the demonstration plant, several types of chute linings were selected for evaluation. Information was also sought on the service life of these materials since some are sold on the basis of extended service life (as compared with ordinary steel life), in addition to their noise reduction potential.

The chute lining materials evaluated included ultrahigh molecular weight plastic and ceramic tiles, as well as sheet rubber. The materials were installed in both open and closed chutes. As expected, the resilient materials had a greater noise reduction potential than the rigid materials. Figure 5 illustrates the noise reduction achieved with rubber chute liners in a closed chute. All of these materials, however, had only a limited effectiveness in open chutes because of the noise inherent in the material flow. The plastic tiles were found to be quite durable when subjected to smooth, sliding flows, but wore quickly when exposed to tumbling or impacting flows. The ceramic tiles, while more durable in tumbling flows, did show evidence of cracking over time. The rubber-lined chutes that handled 1-1/2- by 3/8-in-material also proved to be quite durable as long as the rubber was carefully bonded to the chute walls.

Finally, these tests also confirmed that simply installing covers on open-top chutes can be a very effective, yet relatively low cost, noise control treatment. It should be recognized, however, that this treatment can make visual monitoring more difficult and therefore must be carefully evaluated on a case-by-case basis.

Flexible curtains installed on overhead tracks were used to enclose or separate noisy equipment that could not be treated effectively through other means. These curtains have a number of advantages over rigid enclosures (such as adaptability to dense, complicated equipment layouts and ease of opening or removal for access and maintenance) which are particularly desirable in coal preparation plants. Of concern in this evaluation was not only the noise reduction potential, but how durable they were

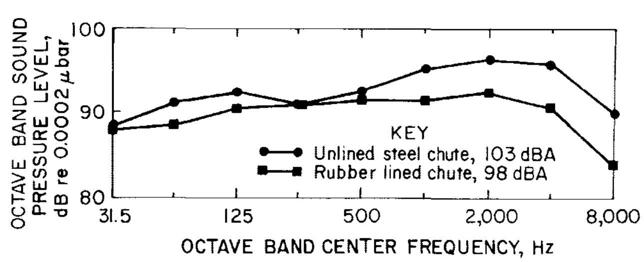

FIGURE 5. - Sound pressure levels measured 6 in. from unlined and lined discharge chutes.

and whether their use imposed any significant operating restrictions on the plant.

The curtains used in this project (primarily fiberglass reinforced, 3/4-lb/ft^2, mass-loaded vinyl) proved to be both effective from a noise control point of view, and very durable. The Velcro hook-and-loop closures were also found to be quite durable when sewn, rather than glued, on the curtains. Figure 6 illustrates the noise reduction achieved by a typical installation. While the presence of the curtains did require that operators open them to make visual inspections, this was far easier than with rigid enclosures. The curtains did not have a major impact on plant operation.

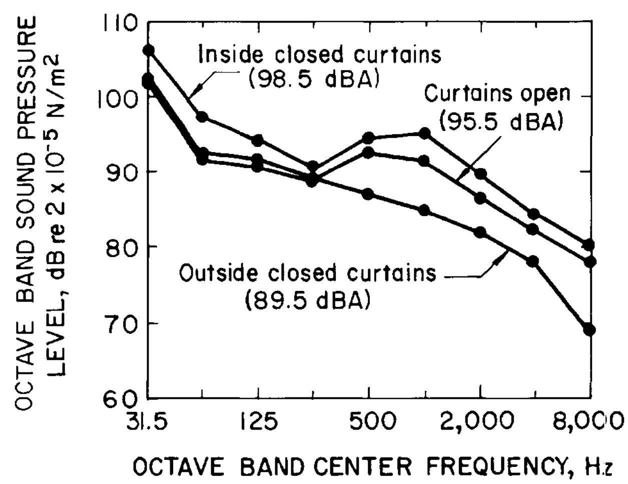

FIGURE 6. - Sound pressure levels measured at Wemco dryer curtains.

NOISE CONTROL FOR NEW FACILITIES

As indicated previously, new preparation plants often require a different noise control approach than do existing facilities. This stems from advances in plant design, as well as the ability to make changes in equipment selection and layout during the design stage. While advances in coal preparation technology occur relatively slowly, the mix and type of equipment being used in new coal preparation plants is constantly evolving. Furthermore, it is sometimes possible, during the design stage of a new plant, to locate equipment and modify specifications to compensate for the effect of noise control treatments. Although there are practical limits to such changes, this design flexibility can shift the balance when evaluating noise control alternatives. In existing plants, the cost of such modifications can be prohibitive and, therefore, limit the noise control options available.

Considering the differences between noise control approaches for new and existing preparation plants, the Bureau initiated a second project (contract J0100018) to study and document those noise control techniques that are suitable for new preparation plants.

Worker noise exposure can be minimized in new preparation plants by both careful plant layout and design, and treatment of individual equipment. Effective techniques during plant layout include isolation of high-noise areas, modification of personnel traffic patterns, and possibly even the selection of alternative processes. Equipment treatment can include selection of low-noise models as well as retrofit treatment of standard equipment.

PLANT LAYOUT AND DESIGN

Isolation of noisy equipment can be important for both mobile and stationary plant personnel. Ordinarily, the noise produced by equipment such as screens, chutes, crushers, and centrifuges propagates from floor to floor through open gratings, machinery wells, and stairways, thus keeping most of the plant at or above 90 dBA. The result is that supervisors, mechanics, and other mobile personnel accumulate unnecessary noise dosages as they move about the plant. In addition, it is not uncommon to find shop areas located adjacent to high-noise equipment, such as vacuum pumps. In such cases, shop personnel may accumulate noise dosages even though their own work in the shop may be relatively quiet.

Providing the necessary isolation at the design stage through careful plant layout, partitioning off machinery wells and stairways, and floor-to-floor isolation (e.g., through the use of concrete floors) is generally more cost effective than resorting to retrofit treatments after the plant is operating to achieve the necessary noise reduction. Figure 7 illustrates one relatively simple method of isolating a main stairway and machinery well from a noisy screening floor.

For equipment that will need to be enclosed, either individually or in groups, careful positioning along exterior walls (or preferably in a corner of the building) can minimize the wall construction costs, as well as any interference with worker traffic patterns, lighting, pipe runs, etc. Positioning enclosed pieces of equipment along outside walls also simplifies ventilation design for the equipment and facilitates exterior venting for blowers. Attended equipment and control panels should also be carefully located to minimize unnecessary noise exposure of personnel. For example, the relatively quiet flocculent mixing station located on the right side of figure 7, which must be attended several hours per day, would be better located on a quieter floor, or placed in a corner to reduce the cost of isolating it from the screening noise.

Remote monitoring of noisy equipment can also reduce unnecessary noise exposure of plant personnel. While video cameras have occasionally been used in some operations, and computer-controlled

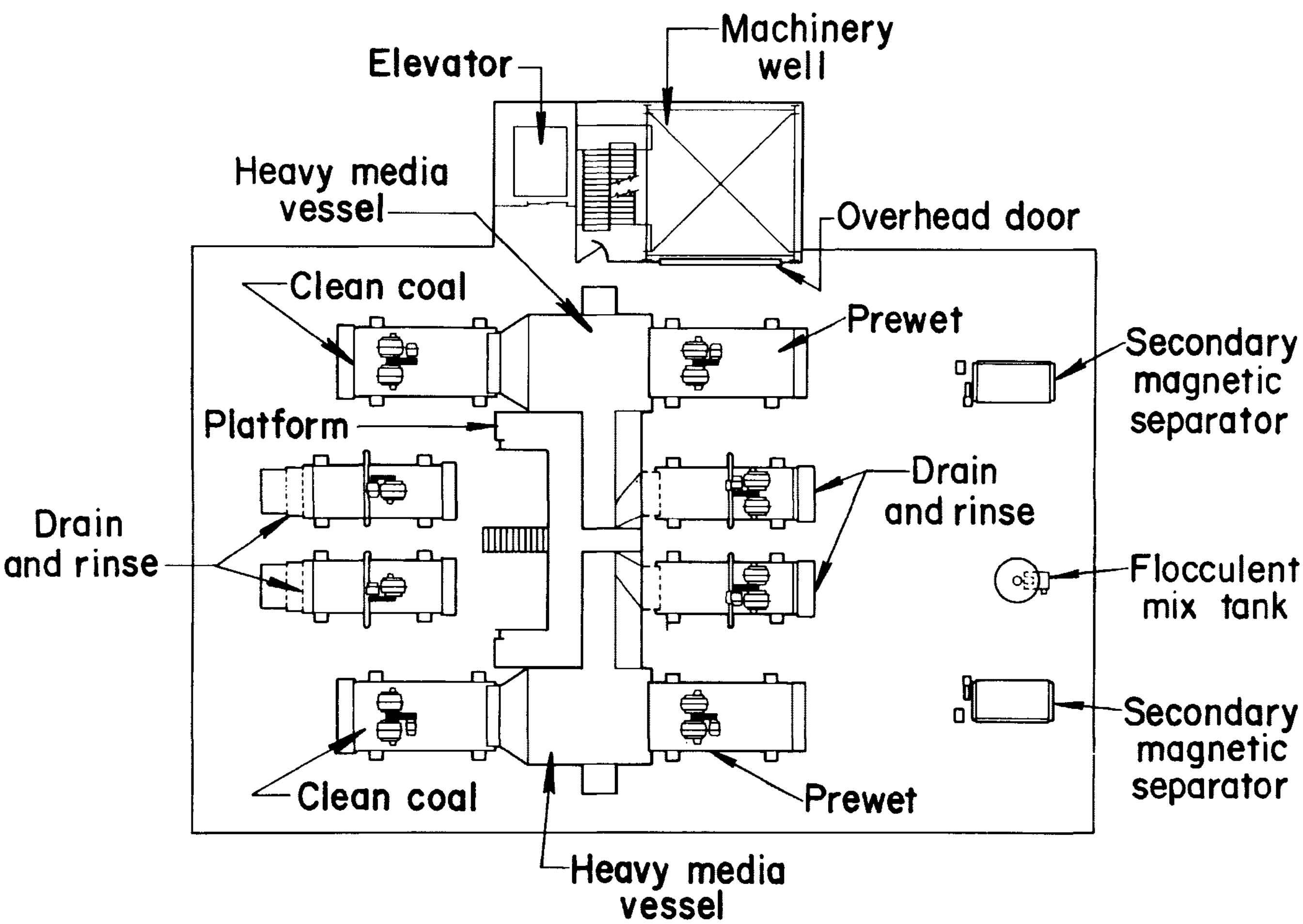

FIGURE 7. - Sample floor plan of screening floor.

equipment monitoring is becoming more common, these systems can be relatively expensive. They are, however, not the only possibilities. One simple technique is to use enclosed, gallery-type observation walkways to provide plant personnel with the desired visual access without exposing them to excessive equipment noise. Figure 8 shows, conceptually, what one of these galleries might look like. Ideally, the walkway would be linked to isolated stairways as described previously.

Although noise is not normally a primary determinant in process design and equipment selection, some of these decisions will have a direct effect on the noise control requirements for the plant. For example, while the noise level of process equipment often increases with the size, it is sometimes easier to isolate a few large pieces of equipment rather than many smaller units. The use of multiple pieces of equipment also tends to distribute the noise throughout the plant, which can make the design of some noise control treatments more complicated.

In terms of how equipment selection can affect the plant noise control requirements, a good example is fines dewatering equipment because the noise varies

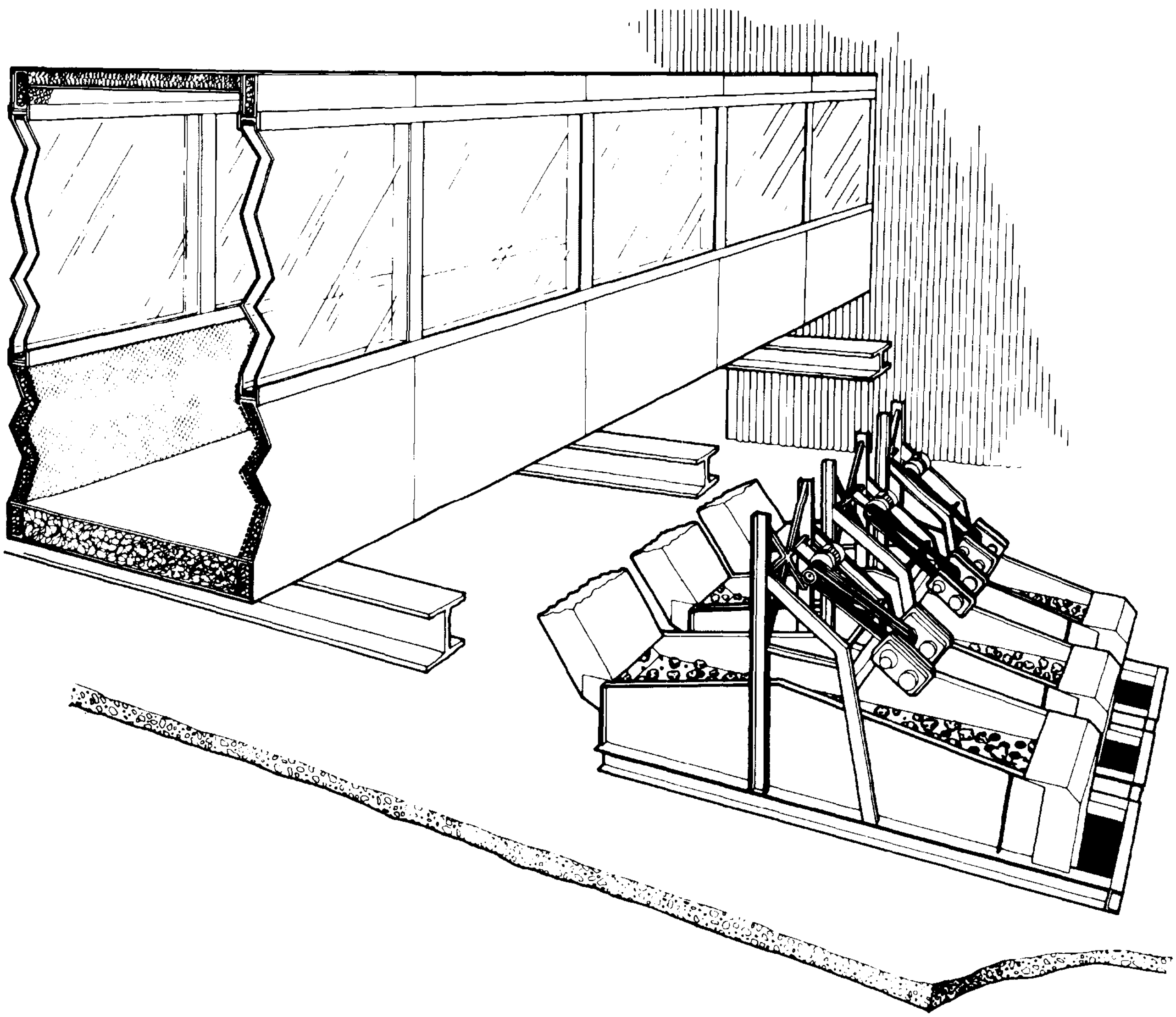

FIGURE 8. - Schematic of gallery-type walkway.

significantly between specific types. Of the commonly used in-plant equipment, vacuum pumps for disk filters tend to be the noisiest, and are capable of producing noise levels over 100 dBA in pump rooms; belt and filter presses can be some of the quietest equipment, capable of operating at less than 90 dBA at typical operator positions.

NOISE CONTROL OF INDIVIDUAL EQUIPMENT

Although careful layout and design of a new plant can simplify and/or reduce the noise control requirements for individual equipment, generally it will still be necessary to specifically reduce the noise of some plant equipment. There are two basic alternatives for noise reduction of plant equipment; (1) specify and purchase low-noise models, where available, and (2) treat the standard equipment using retrofit treatments. There will also be instances when a combination of the two represents the most appropriate approach.

Electric motors are probably the best example of equipment for which low-noise models are commercially available. While not the noisiest equipment in preparation plants, electric motors are used throughout the plant and can result in a significant noise problem, particularly when grouped together (such as on a pump floor).

The design features that are incorporated into low-noise motors include low-noise fans (typically unidirectional fans), class F insulation that allows the motor to operate with less ventilation, better aerodynamic design of the housing and end frames, and better bearings for reduced mechanical noise. These features result in motors that are significantly quieter than standard designs; this is evidenced by comparing the sound spectra shown in figure 9 for comparable Westinghouse 150-hp TEFC motors.

Furthermore, some of the features that make a motor quiet also make it more efficient, and some manufacturers have incorporated these low-noise features into their line of energy-efficient motors. For instance, GE's line of energy-efficient motors are approximately 3 pct higher in efficiency than its standard motors and produce sound levels comparable to its low-noise motors. These motors are about 25 pct more expensive than the standard units; depending upon hours of operation and power cost, they can have payback periods on the order of 1 to 4 yr. The noise control, therefore, can be obtained at no extra cost in the long run.

Vacuum pumps are another example of equipment for which low-noise versions are commercially available. Currently, it is possible to purchase treated ver-

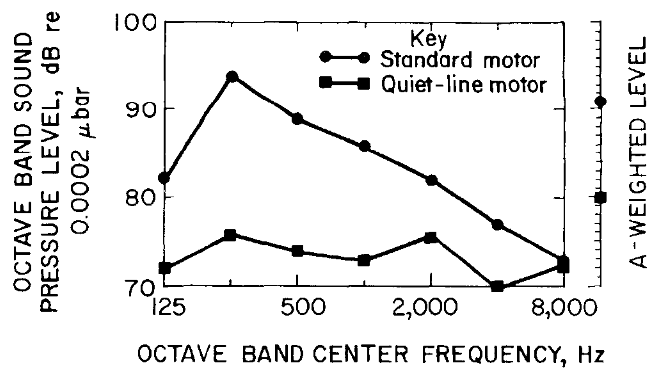

FIGURE 9. - Comparison of octave band sound pressure levels for a TEFC Westinghouse 1,800-rpm, 150-hp standard motor versus quiet-line motor (typical no-load sound pressure levels at 3 ft in a free field).

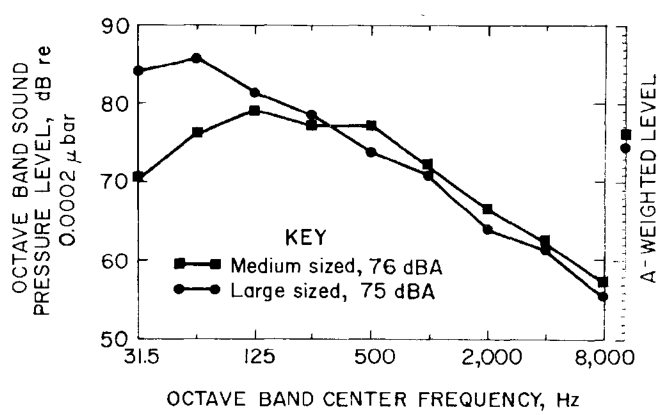

FIGURE 10. - Sound spectra for Siemens ELMO-F vacuum pump. (Adapted from Siemens AG data sheet E-726/1086-101.)

sions of the commonly used positive displacement, rotary-lobe pumps, as well as liquid-ring vacuum pumps that are inherently quieter than the positive displacement pumps because of basic design differences. Figure 10 shows the sound spectra that Siemens specifies for two of its typical liquid-ring pumps. Liquid-ring vacuum pumps, however, are more expensive than positive displacement types, and require seal water with relatively low solids content and neutral pH.

As discussed earlier, retrofit noise control treatments for preparation plant equipment have been the subject of Bureau investigations for some time. Work cited in footnotes 5 and 6 provide detailed discussions of a number of these treatments. Not only are these treatments applicable to new preparation plants, many are also easier to incorporate into new plants because of the flexibility available at the design stage. Resilient chute linings and impact pads are notable examples since the sizes, angles, and mounting configurations of the chutes can be optimized at the design stage to facilitate the use of these materials.

SUMMARY

This paper, of course, discusses only a few of the wide variety of noise control techniques available to preparation plant operators and designers. Many of the retrofit treatments that were field tested under early Bureau contracts proved to be both effective and durable. The design concepts studied more recently for new plants provide plant designers with techniques to minimize unnecessary noise exposure and thereby reduce the eventual noise control costs.

While there are some plant areas that can benefit from additional research, the techniques and materials that are currently available make it possible to achieve meaningful reductions in the noise exposures of personnel for both new and existing plants.

Information Circular 8986

Noise Control

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

Compiled by Staff, Bureau of Mines

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

BUREAU OF MINES
Robert C. Horton, Director

Library of Congress Cataloging in Publication Data:

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

Noise control.

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

Includes bibliographies.

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

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

TN295.U4 622s [622'.4] 84-600194