6. CASE HISTORIES

The case histories presented here are intended to be useful to production and safety engineers, health personnel, and other factory personnel who are not specialists in noise control. The case histories are examples of engineering tasks that have been completed not only by professional noise control engineers but also by nonacoustical specialists who used common sense to solve their noise problems. Collected here are actual cases on various industrial devices. These devices were typically machines used in a production process; in some cases, they had been cited by safety officials for unsafe high sound levels or by regulatory agencies for violating local noise ordinances.

The case histories presented here were chosen primarily because the amount of noise reduction actually achieved was measured. Such engineering results, even if not directly applicable to your situation, illustrate general principles that will point the way to a successful result for your problems. Toward that end, the treatments are described in detail in these case histories.

CASE HISTORY DATA

The following outline presents the whole process of accomplishing noise control, viable in both engineering and economic senses. The outline will also serve as a check list to guide you in learning and applying the principles of noise control engineering that have been discussed earlier. The case histories that follow contain the essential data for the simpler problems and somewhat more for the complicated ones.

OUTLINE OF COMPLETE PROCEDURE FOR DEVELOPMENT OF NOISE CONTROL

1. Plant data

   - SIC classification of industry
   - Location, address; division
   - Product or process

2. Problem definition

   - Compliance plan
   - Compliance measurements, daily noise dose

- Diagnostic measurements and source locations
- Design of experimental noise control
- Design of final noise control
- Supervision of construction, installations
- Post-installation checkout, performance evaluation
- Oral briefings
- Preparation of technical paper

3. Machine data

3.1 Identification

- Make, model, serial number, factory number
- Appearance (drawing or photo); identification of significant parts, functions
- Layout drawing of workroom, all machines shown
- Location of aisles, vertical clearances; service lines; conveyors; hazard-posted areas

3.2 Operating data

- Functions of machine; relation to others
- Type of input: gauge, size, shape of stock
- Type of output: shape, size
- Type of scrap: how collected
- General product flow with respect to other machines
- Use of automation: conveyors, robots
- Services and ratings: electrical, air, water, fuel, steam, hydraulic, internal combustion engine, vibrator
- Production rate (maximum)
- Downtime: jams, breakdowns; repair, maintenance, set-up; reload, idling; operator at rest room, meals
- Constraints on operation: access, both physical and visual, for worker, input stock, output product, and scrap; access for repair, maintenance, set-up, reload; safety, union regulations, sanitation, special materials for food industries, rodent control; operator need for aural cues; limits on capital and operating expenses
- Special machine features: noise control features already installed; use of vibration isolators; use of air; evidence of overlubrication

4. Noise situation data

4.1 General observations (ear)

- Noise high or low pitched
- Directional location by cupping hands behind ears
- Presence of pure tones
- Level constant, varying slowly or with much impact noise
- Feeling of vibration in floor
- Workers communicating by word or sign
- Use by workers of aural cues in detecting and evaluating machine performance, jams

4.2 Name, make, model, S/N

- Calibration data: when; traceable to NBS
- Check list for diagnostic acoustical measurements: SLM, octave-band analyzer, 1/2-in. and 1-in. microphones, tripod, extension cord for microphone; windscreens, calibrator and adaptors; accelerometer; control box for acceleration, velocity, displacement; stroboscope; vibrating reed tachometer
- Check list for optional equipment for diagnostic acoustical measurements: two-channel tape recorder, connecting cords, microphones for voice channel, blank reel, AC cord, charger; range finder, measuring roller, steel tape (centimeters and inches); flashlight; pressure-sensitive labels; camera with wide-angle lens, flash; spare batteries for all equipment (alkaline only); ear muffs, safety glasses, safety shoes, hard hat, paper towels, handsoap; pliers, diagonal cutters, screwdrivers; circuit tester

4.3 Acoustical measurements

- A, C, peak and octave-band readings
- Measure at ear positions of worker, worker absent, if possible, with all machines going, then with machines in question selectively turned off
- Run machine at different speeds to locate resonances
- Run with portions of machine selectively disabled
- Measure rpm's with stroboscope, vibrating reed tachometer
- Measure at suspected noise sources on machine; photograph the set-ups; locate microphone precisely

The following pages contain 61 case histories. Some are printed in this *Manual* for the first time; others appeared – in a slightly different format – in the 1975 edition of the *Manual*. Case histories written for this edition contain the names of the contributors.

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- Set to octave band for which A-weighted spectrum at ear of worker maximizes. Probe around machine to locate sources.
- Locate around machine an imaginary box that touches all major surfaces; record the dimensions; at 1 m away from box, obtain sound levels for calculating total sound power.
- On slow A-scale, obtain contours of equal sound level around machine, others off; locate paths of workers among contours. Repeat with all machines on.

4.4 Vibration measurements

- C, peak and octave-band readings
- Probe over the surface (pickup coupled so it is not rattling) for acceleration levels
- Calculate velocity and power levels for selected surfaces
- Run machine at different speeds to locate resonant excitation of vibration
- Selectively disable parts of machine to locate exciting sources

4.5 Auxiliary data

- Data per (3.2)
- Unusual conditions: breakdowns; machine with bad bearing, gears, loose parts
- Tape recordings of noise situations that are short-lived or nonrepetitive, together with calibration signal; also useful for later narrowband analysis, judging rpm, pure tones
- Photographs of all pertinent parts of machine, including close-ups of name plate
- Names, position, and possibly addresses of operating, supervisory, and management personnel concerned
- Time of entry to plant, time spent at each machine, time left plant

5. Development of noise control

5.1 Preliminary report

- Data, raw and reduced; evaluation, interpretation
- Preliminary noise control recommendations, taking full account of constraints in (3.2) above

- Preliminary estimate of noise reduction expected
- Preliminary estimate of capitalized installed cost
- Preliminary estimate of possible change in productivity and change in piece part cost
- Recommendations on use of automation
- Conference to discuss implications of report

5.2 Development of revised recommendations

- Remeasure as needed
- Re-estimate noise reduction, costs
- Prepare recommended experimental program if problem sufficiently unusual
- Prepare sketches showing acoustically essential features of the noise control devices; if required, prepare drawings
- Recommend special materials; provide alternate suppliers
- Estimate construction, installation costs

5.3 Installation, use

- Monitor construction and installation for adherence to acoustical specifications
- Introduce corrective measures for improperly installed devices
- Evaluate emergency alternate materials
- Measure installed performance; correct deficiencies
- Measure daily noise dose to applicable workers

6. New work

- Recommend improvements if similar noise control is to be applied to other machines of the same class
- Recommend action on problems remaining
- Provide briefings on results to technical and management people
- Prepare paper for publication
- Help prepare formal compliance reports

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TECHNIQUES THAT INVOLVE MINIMAL EQUIPMENT MODIFICATION

Operator Booth Treatments (see Operating Procedures
Total Enclosures)

Case History 1: Paper Machine, Wet End

Room Treatments (see room treatments)

Case History 2: Gas Turbine Test Station

Vibration Isolation Treatments (see Vibration Control)

Case History 3: 800-Ton Blanking Press

Case History 4: Nail-Making Machine

Damping Treatments (see Surface Damping)

Case History 5: Pneumatic Scrap Handling

Case History 6: Parts Conveying Chute

Case History 7: Plastics Scrap Grinder

Case History 8: Hopper Noise

Case History 9: Electric-Powered Towing Machine

Simple Machine Treatments (see Simple Machine Treatments)

Case History 10: Blanking Press Ram

Case History 11: Spinning Frame

Case History 12: Boxboard Sheeter

Case History 13: Carding Machines

CASE HISTORY 1: PAPER MACHINE, WET END
(OSHA Noise Problem)

Problem Description

The major noise sources of the wet end of this paper machine were the couch roll suction air movement, the pumps, and the whipper roll. The whipper roll supplies a beating action on the felt of the paper machine to provide continual web felt cleaning.

Problem Analysis

The sound level at the wet end is 92 to 94 dBA in the operator aisle. Higher readings of more than 100 dBA were obtained close to the couch roll. See Figure 6.1.1 for a sketch of the area.

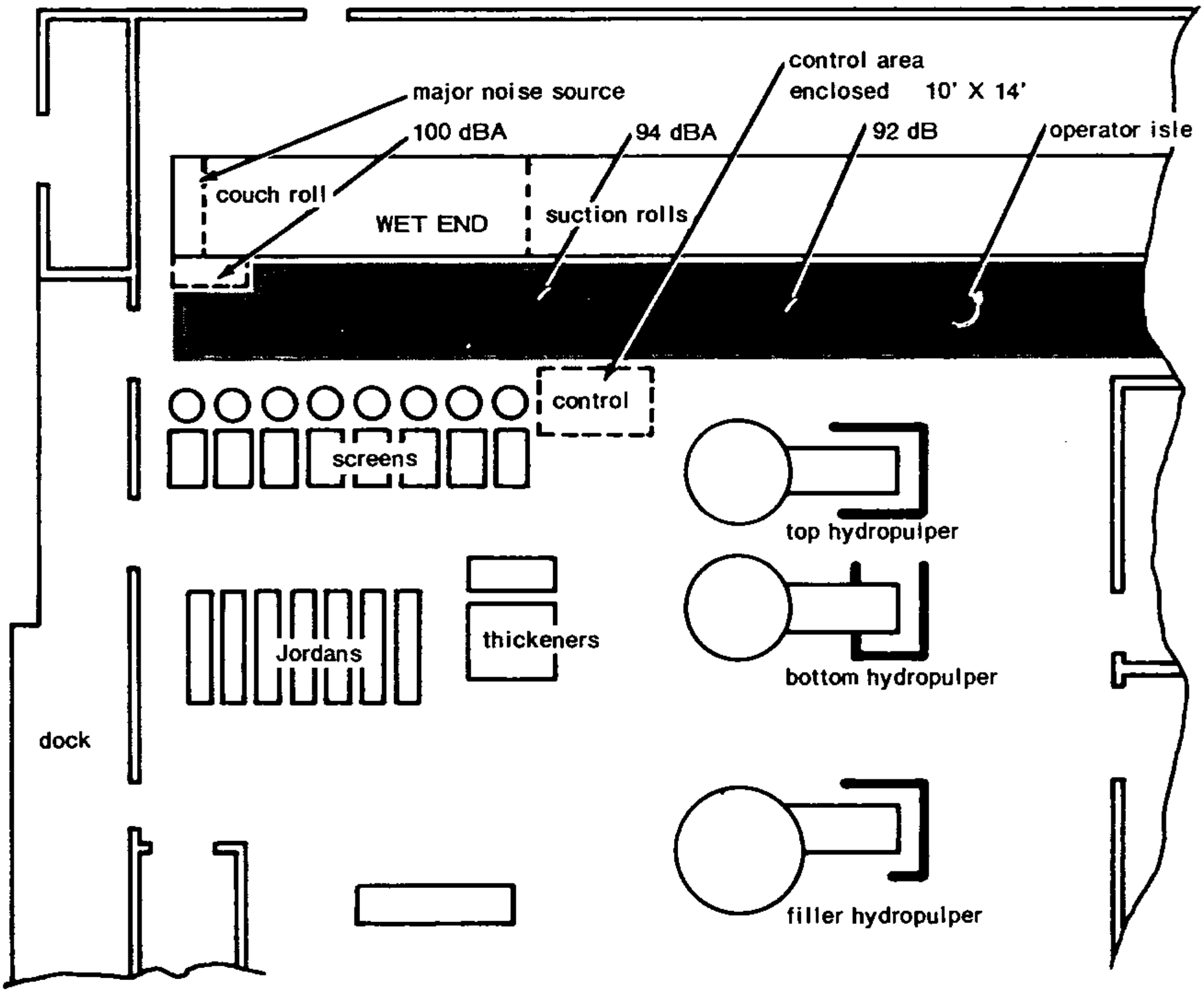

Figure 6.1.1. Paper mill – wet end.

Paper machine manufacturers have developed a quieter couch roll in which the suction holes in the drum are in a staggered, rather than a regular, pattern. However, the replacement cost of a couch roll is high, and it will probably be used only on mill expansion projects or new mill construction.

An alternative method to reduce the operator noise exposure was construction of a personnel booth to house the operator and the operating controls during most of the operating shift. The wet end paper machine operator spent an hour or less making couch roll adjustments during a typical operating day. If the balance of each day were 92- to 94-dBA exposures in the mill operating aisle, the resulting exposure would exceed the OSHA limits. However, if the operator spent the 1 hr at 100 dBA (couch roll adjustments), 2 hr on general observations near machine at 92 dBA, and the balance of the shift in areas under 90 dBA, including a personnel booth, his daily noise dose would be:

$$\underset{(100\text{ dBA})}{\frac{1\text{ hr actual}}{2\text{ hr allowed}}} + \underset{(92\text{ dBA})}{\frac{2\text{ hr actual}}{6\text{ hr allowed}}} = 5/6 = 0.83.$$

Since this dose is less than 1.0, it is within the allowable noise exposure of the present OSHA regulation.

Control Description

The recommendation for the wet end of the machine (couch roll and whipper noise exposure) was to provide an operator enclosure with operating controls and instruments, and with viewing windows to observe machine operation.

Calculations indicated that the required 15-dB attenuation could be attained with a simple structure consisting of 2 × 4-in. framing with 1/2-in. plywood walls inside and out, plus one solid door and two windows 3 × 5 ft each, double glazed. The ceiling and upper half of walls were covered with acoustic tile to reduce reverberant noise. The room was provided with light, heat, and air conditioning for worker comfort. In-plant construction cost was $2,500.

Results

Results achieved by the enclosure are shown in Figure 6.1.2. Inside sound level was reduced to 75 dBA, from outside levels of 92 to 94 dBA.

Greater attenuation can be obtained by purchasing special acoustic shelters or by using more elaborate (from acoustic standpoint) construction such as concrete block walls, double windows, or interior sound absorption.

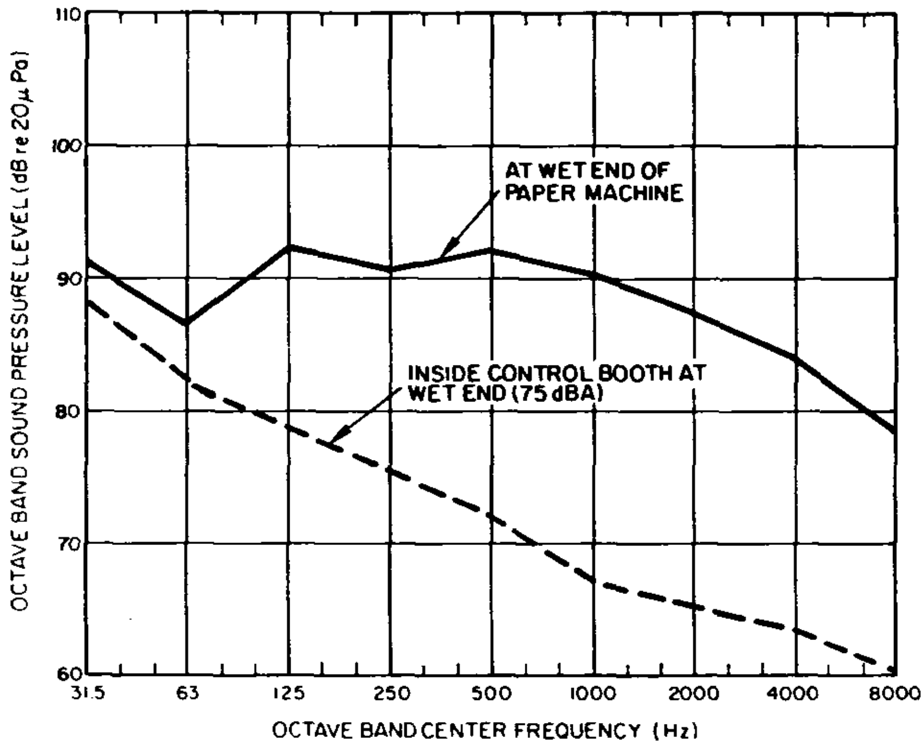

Figure 6.1.2. Sound pressure levels at wet end of paper machine.

Comments

Most of the difficulties to be avoided are nonacoustical. It is essential that the operator has no interference with visual monitoring of machine operation. This consideration fixes the booth location and window placement.

CASE HISTORY 2: GAS TURBINE TEST STATION
(Hearing Conservation and Speech Communication Noise Problem)

Walt Jezowski
General Electric Company
Gas Turbine Division
Building 53-303
Schenectady, New York 12345
(518) 385-7544

Problem Description

Operations of a gas turbine test stand at the General Electric Company's Schenectady, New York plant involve fabrication and assembly workers on the 128,000-ft^2 workfloor surrounding the test area. In particular, sound between 90 and 95 dBA was at times present in the vicinity of the test stand where some 40 employees work for varying periods of time.

Problem Analysis

The test station responsible for the high sound levels is partially treated; the test stand is surrounded by a 14-ft-high acoustically lined, open-topped barrier. Noise is emitted over the top of the partially enclosed test area, which remains open for crane accessibility. Alternatives for reducing the sound levels in the area surrounding the stand narrowed to treating the room surfaces to reduce the effects of reverberation. Hanging baffles, wall and ceiling blanket linings, and spray-on materials were investigated, the latter eventually being selected for implementation. Prior to installation, estimates of the expected acoustical benefit were made on the basis of calculations of the existing and modified room constants.

Control Description

The selected treatment consisted of a 1-in.-thick layer of sprayed-on cellulose-fiber-based material called K-13, available from National Cellulose. The material is applied directly to the surface to be coated, where it forms a permanent thermal and acoustic lining. In this installation, approximately 28,000 ft^2 of ceiling and wall area were coated at a cost of about $\$1.10/ft^2$.

Results

Aisle sound levels were reduced, as predicted, from 95 dBA to 90 dBA, as shown in Figure 6.2.1. The manned area surrounding the test stand with above-90-dBA sound levels has been eliminated.

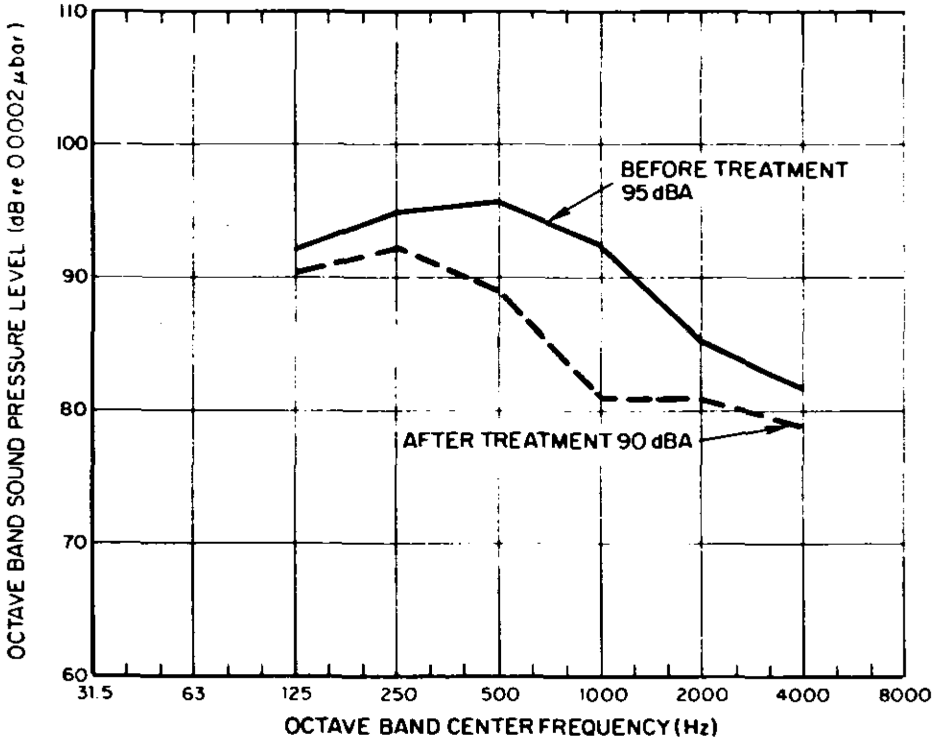

Figure 6.2.1. Reduced aisle sound levels, as predicted.

Comments

In addition to having improved the acoustic environment, General Electric also achieved added thermal insulation. Annual savings of about 13¢/ft^2 are estimated in heating costs for the treatment – one of the major reasons for selecting a surface-applied material. Additional benefits include lower maintenance costs (there is no longer the need to paint the 65-ft-high ceiling and wall areas) and improved light reflection and diffusion.

CASE HISTORY 3: 800-TON BLANKING PRESS (OSHA Noise Problem)

Problem Description

The 800-ton Verson press is a massive unit weighing about 275,000 lb, and mounted on four footings set on heavy concrete piers. Production on this press was automobile chassis steel sections of 1/4-in. steel about 10 in. wide and 8 to 10 ft long. Normal operating speed was 30 strokes/min. Steel stock was fed to the press from a reel. Noise levels were about 120 dB on impact, 105 dB at quasi-peak, and 94.5 dBA at operator location, which was about 4 ft in front of the press.

Problem Analysis

As a starting point to the total solution of the noise problem, it was decided to vibration-isolate the press and determine the attenuation gained before working on other noise sources, which are not part of this case history.

The press was operated in a single shot mode. Hence, quasi-peak readings for each octave band were more meaningful for ear effect than rms readings (slow A-scale). The peak value is the maximum level reached by the noise, whereas quasi-peak is a continously indicating measure of the average (over 600 msec) of the high levels reached just before the time of indication and is thus lower than the actual peak, but greater than slow A-scale values.

Vibration data were recorded for the support foundation, floor near press, adjacent building column, and press structure at the press feet, before and after installation of the isolators.

Control Description

From the data supplied on strokes per minute and press weight, the isolators were specified to be Vibration Dynamics Corporation (of La Grange, Illinois) series BFM micro/level isolators, under the press feet. No price lists are available because each isolation problem is specifically engineered and quoted. Cost was about $2,000 for the isolators, and installation by in-plant labor was probably about $1,000.

Results

Adding isolating pads reduced the vertical acceleration at the pier by 9.5 dB, as shown in Figure 6.3.1. Most of the reduction occurred in the 2-, 4-, and 8-kHz bands. The vertical foot-to-pier acceleration reduction was 30 dB.

Figure 6.3.2 shows the horizontal acceleration at the pier. Adding isolation effected a 12-dB reduction in acceleration. The

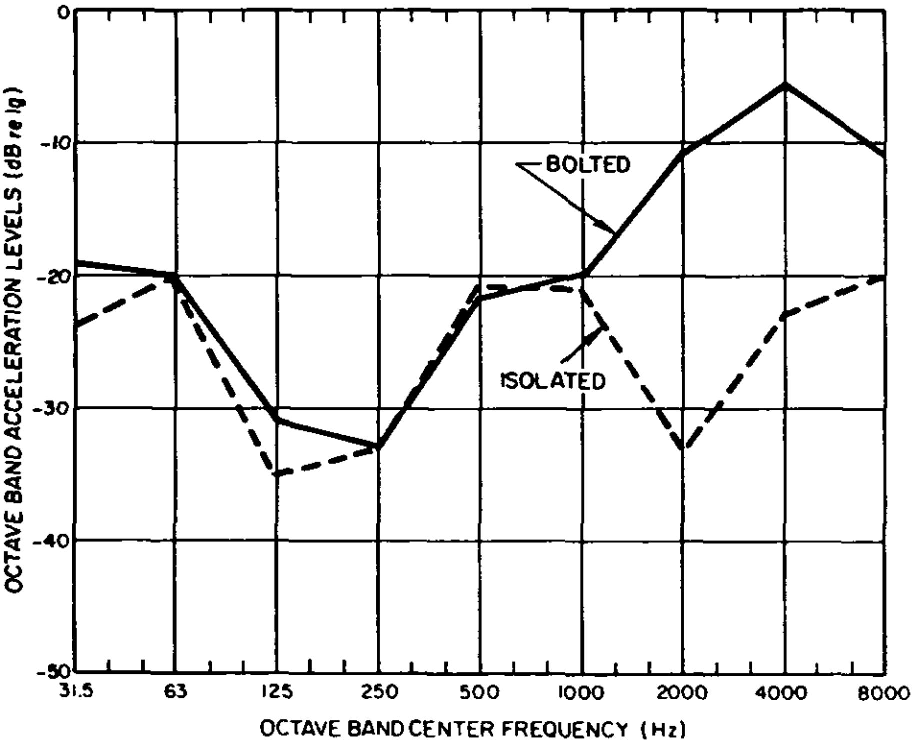

Figure 6.3.1. Vertical acceleration on pier, before and after isolation.

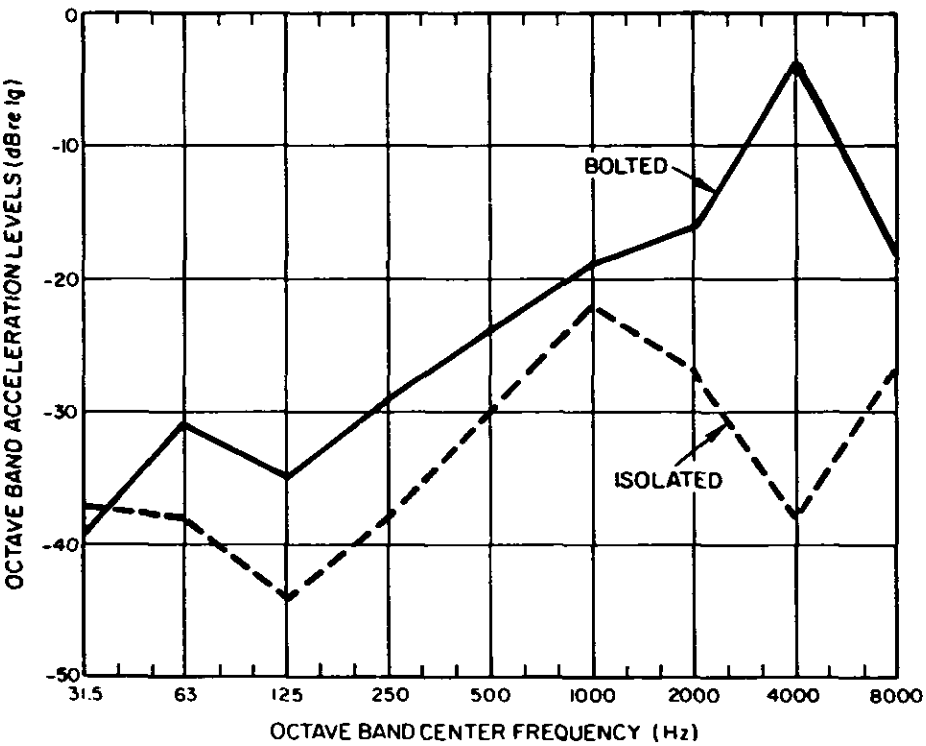

Figure 6.3.2. Horizontal acceleration on pier, before and after isolation.

horizontal foot-to-pier acceleration was reduced 36 dB by the isolating pads. Note that it is the vertical motion that is responsible for most of the sound radiated by the floor.

Figure 6.3.3 compares the sound pressure level readings at 4 ft before and after isolation (quasi-peak readings, single shot operation). The calculated dBA levels show a reduction of 6.5 dB in the sound level.

Isolators reduced vibration in support foundation, floor, building, column, and pressure structure. It has been found that a primary cause of background, or ambient, noise is the vibration in the building structure, which is presumed to be caused by the anchor bolt after-shock.

Calculation here shows that there was a 105-dBA quasi-peak sound level before isolation and a 98.5-dBA level after isolation. With a relationship of about 10 dB quasi-peak to rms, a reduction in level from 94.5 dBA to 88 dBA at operator location has been made. Additional presses will add their own noise and will increase levels to above 90 dBA. Other operational noise sources in the press must be controlled separately.

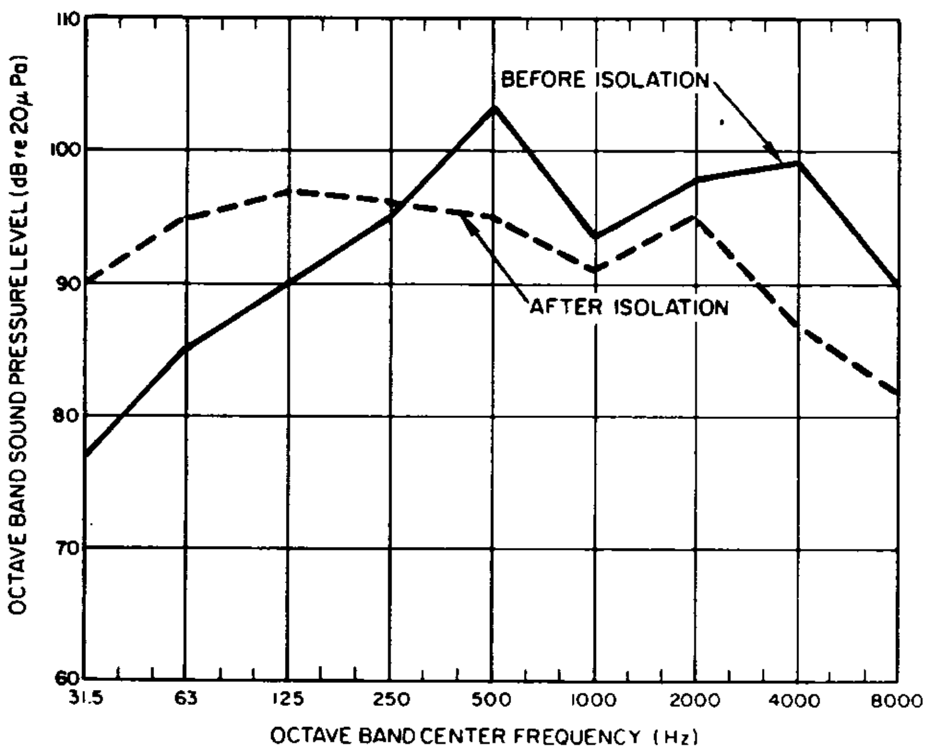

Figure 6.3.3. Quasi-peak levels 4 ft from press foot, before and after isolation.

Comments

The major pitfall of this approach is that airborne sound level reduction from vibration isolation is almost impossible to predict. However, a serious noise control program in such operations should include isolation devices for all presses.

A reward is that the die life and maintenance of such machines is significantly increased for presses that are vibration-isolated. Isolators improve operation and maintenance by reducing failures of anchor bolts, foundation failure, or breaking of press feet.

CASE HISTORY 4: NAIL-MAKING MACHINE*
(OSHA Noise Problem)

Problem Description

A nail-making machine was operating under conditions causing severe impacts. The vibration was solidly transmitted to a weak concrete floor, which radiated considerable noise. There were 10 machines, operating at 300 strokes/min. Operator sound level was 103.5 dBA.

Control Description

It was decided to use vibration-isolating mounts to reduce floor-radiated noise. Because of the repeated shock situation, selection of the isolator followed these rules:

(1) The natural period of isolator plus machine should be much greater than the shock pulse duration (10 msec).

(2) The natural period of isolator plus machine should be less than the time between pulses (200 msec).

Elastomer-type isolators were used, which had a static deflection of 0.1 in. under machine load. This corresponds to a natural period of 100 msec, thus fulfilling the design conditions.

Results

Figure 6.4.1 shows octave-band spectra at the operator's position after all machines had been vibration-isolated. The sound levels have been reduced about 8.5 dB to 95 dBA, a level still in excess of permitted levels. Additional noise control is needed.

Comments

To maintain the isolation, maintenance people should be warned not to short-circuit the isolators by any solid connection from machine to floor. This short-circuiting can also occur when dirt and grease are allowed to build up around the pods.

As a reduction to a sound level of 95 dBA is not considered satisfactory for full-day operator exposure, additional noise reduction could be obtained by the design of a barrier between the major noise source in the machine and the operator. Depending on the needs for vision through the barrier, plywood, lead-loaded vinyl curtain, or Plexiglas could be used. Such a barrier should yield

*From Crocker, M.J. and Hamilton, J.F. 1971. Vibration isolation for machine noise reduction. Sound and Vibration 5 (11): 30.

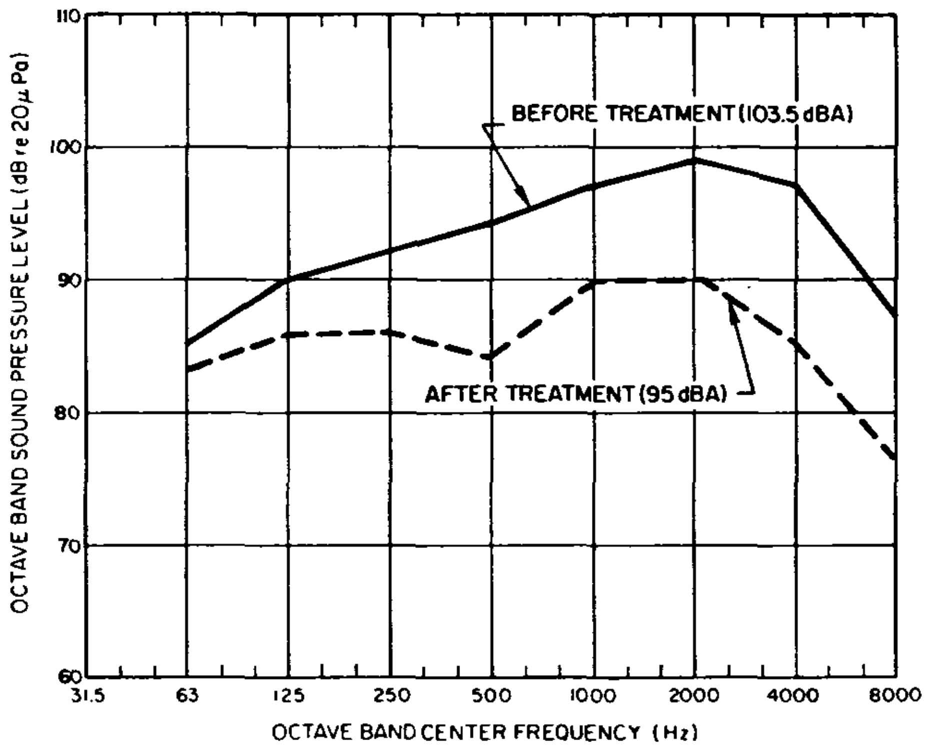

Figure 6.4.1. Operator position sound pressure levels, before and after treatment of nail-making machine.

a reduction of 5 to 8 dB at the operator position. (For calculated design parameters, see Case History 52 and for rule-of-thumb parameters, see Case History 14.) This noise reduction should result in lowering of the sound level to 87 to 90 dBA.

Where there is a series of machines, additional reduction of several decibels could be obtained by added room absorption, either in the form of spray-on acoustic absorbent on ceilings and walls or in the form of hanging absorbent baffles from the ceilings.

CASE HISTORY 5: PNEUMATIC SCRAP HANDLING (OSHA Noise Problem)

Problem Description

In the folding carton industry, printed sheets are cut on Bobst and similar cutting presses equipped with automatic strippers for removal of waste material between cartons. When the press is operated and is in good mechanical adjustment, there is no serious noise problem. Often, however, noise from the scrap disposal system results in sound levels above 90 dBA on the pressman platform.

This popular scrap disposal system (see Figure 6.5.1) uses a horizontal air vane conveyor to move the scrap from under the stripping station to the intake of a centrifugal fan that pushes the scrap to a baler or to bins at a baler in a remote location.

The noise problem arises from the pieces of paper scrap striking the sides of the intake conveyor under the press stripper, the sides of the intake hood to the fan, and the fan and outlet ducts. All these contributed noise that resulted in sound levels of over 90 dBA at the pressman station. Depending on amount of scrap and size of pieces, the sound level reached 95 dBA on each stroke of the press, normally making the noise almost continuous.

Problem Analysis

In this type of problem, it was not considered necessary to make octave-band measurements when simple direct sound level readings would tell the story of the obvious problem before and the results after damping. Octave-band sound pressure levels aid in determination of the noise source, but in this case the noise source was known and before-and-after levels could be expressed in dBA.

Control Description

The sheet metal of the stripper intake, fan intake from horizontal air vane, the fan, and outlet ducts were all damped (and transmission loss improved) by gluing a layer of lead sheeting to the outside surfaces, using a resin glue recommended by the supplier of the sheeting. Sheeting used was 1/32-in. thick, 2 lb/ft^2.

Other sheet damping materials that are on the market could have been used as effectively, as discussed below.

Results

The damping of the sheet metal reduced the sound level at the pressman platform to 88 to 90 dBA.

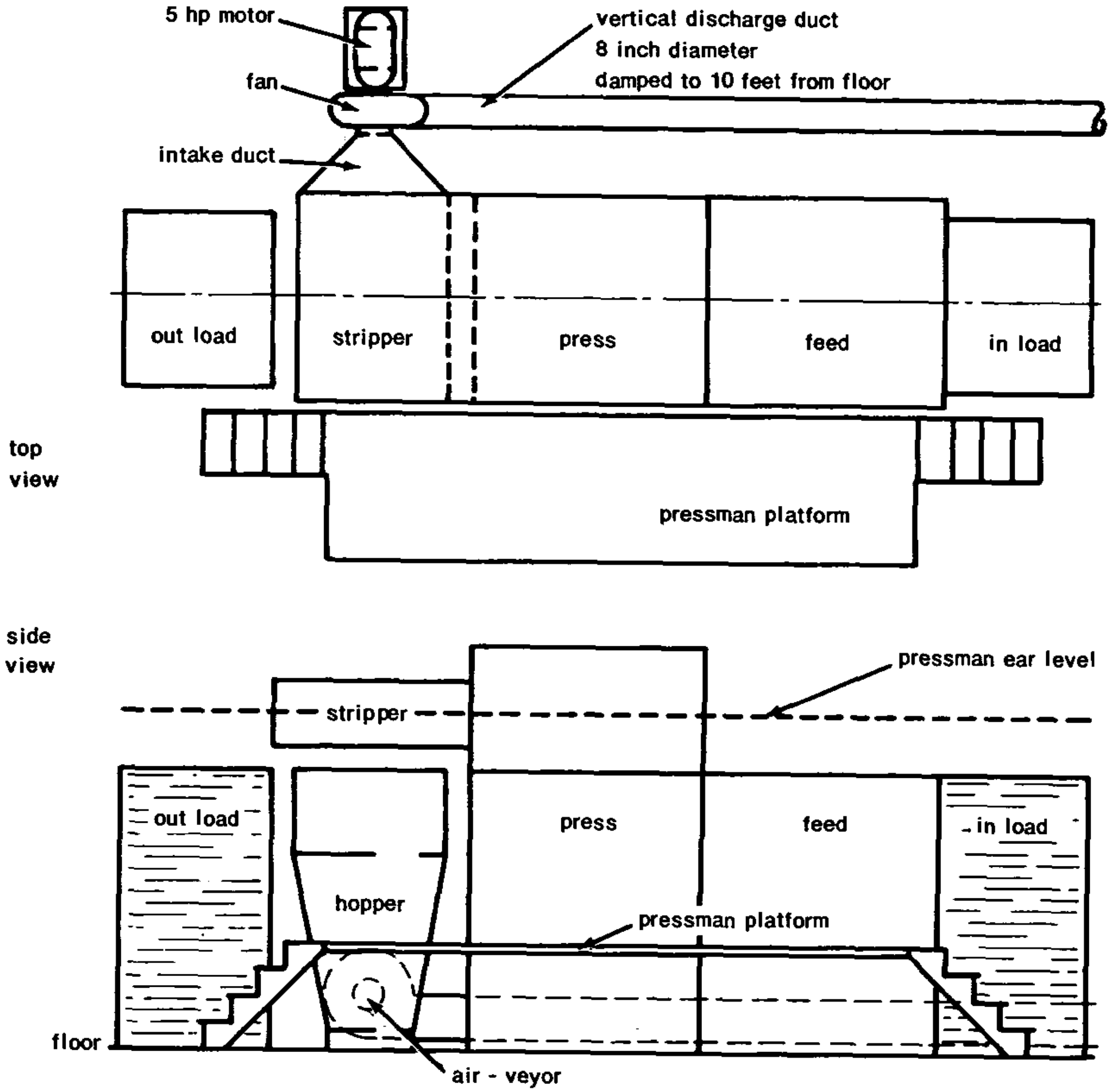

Figure 6.5.1. Scrap handling system for cutting press.

The concept of using sheet lead to damp the sheet metal ducts came from supplier literature citing successful sheet metal damping on ducts and fans and other surfaces. (Cost is about $0.90/ft^2.) For less damping, a 1 lb/ft^2 material may be used at $0.46/ft^2. For minimum damping, stiff roofing felt may do. For even greater damping, there are many products on the market in sheet form and tape form. Suppliers can be consulted on specific problems; prices range from $1.50 to $3.50/ft^2.

For very high vibration and sound levels, a further duct treatment step would be lagging, which is a spring-absorber-mass combination of 1 to 3 in. of resilient acoustic absorbing material (glass fiber or polyurethane) with a heavy cover sound barrier of sheet lead or lead-loaded vinyl sheeting over the entire surface.

CASE HISTORY 6: PARTS CONVEYING CHUTE
(OSHA Noise Problem)

This case was taken from published data,* because of the importance of illustrating the method for other applications.

Problem Description

Chutes for conveying small parts can radiate much noise from the impact of parts on the sheet metal of the chute. The noise (for a given part) can be reduced by keeping to a minimum the distance the part must fall to the chute. For reducing the remaining noise, the chute can be stiffened and damped.

Control Description

Constrained layer damping is used, in which the treatment can be placed on either the parts side or the underside of the chute. If placed on the parts side, the metal layer should be wear-resistant to the impacting parts. In this example, 30-caliber cartridge cases were carried in the chute shown in Figure 6.6.1.

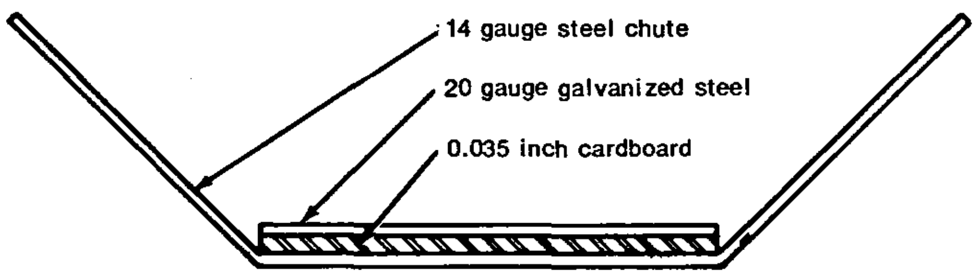

Figure 6.6.1. Chute for conveying cartridge cases.

The bottom of the chute was 14-gauge steel, which was lined with 0.035-in. cardboard and then covered with a wear plate of 20-gauge galvanized steel. Rubber deflector plates were positioned to funnel parts to the center of the chute, so that they would not hit the untreated sides of the chute.

Results

Figure 6.6.2 shows the spectra measured 3 ft to one side of the chute. The sound level has been reduced from 88 dBA to 78 dBA, a decrease of 10 dB. Greater reduction could have been obtained

*Cudworth, A.L. 1959. Field and laboratory example of industrial noise control. Noise Control 5 (1): 39.

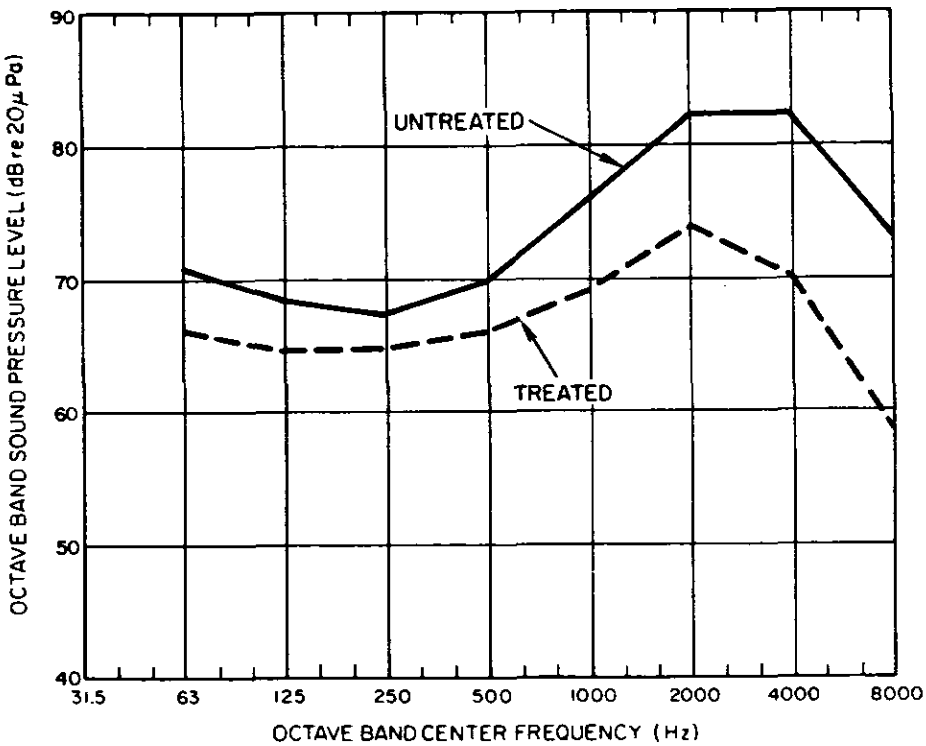

Figure 6.6.2. Sound pressure levels measured 3 ft from chute (converted from old octave-band designations).

if multiple layers of thinner cardboard were used (in solid contact with the cover sheet). Still better would be replacement of the cardboard by commercially available damping materials specifically formulated for constrained layer use.

Comments

Much noise still comes out of the top of the conveyor. A cover over it, lined with absorbent, should reduce the noise an additional 5 to 10 dB. Prior to any noise control effort, the relative amounts of noise from top and bottom should be determined.

CASE HISTORY 7: PLASTICS SCRAP GRINDER*
(OSHA Noise Problem)

Problem Description

In the molding room, primary noise sources are scrap grinders and plastic granulators. The noise has increased during the past few years because of the growth in the number of grinders and increasing toughness of the newer plastics.

Problem Analysis

Sound level maxima of 125 dBA in the initial grinding phase have been recorded, and 100 dBA is common.

Control Description

Although the optimum mechanical conditions of the plastics scrap grinder, such as sharp blades, proper screen size, blade-to-screen clearance, and proper feeding procedures, help reduce grinder noise on existing equipment, this alone could not bring the unit within acceptable noise limits. Much of the noise came from resonant excitation of metal panels.

A damping material was applied to all surfaces; hopper, interiors of pedestals, stands, and covers. In general, a 1/4-in. coating has been satisfactory for most grinders from bench models to 18- × 30-in. throat grinders.

Results

The before-and-after results of the treatment, shown in Figure 6.7.1 (each for one load of 4 lb of polycarbonate), bring sound levels down to the OSHA criterion, reducing the maximum sound level from 100 dBA to a range of 88 dBA to 90 dBA.

Comment

Some manufacturers now offer quieted versions of plastics pelletizers for sale.

*Morse, A.R. July 1968. Plastic Technology.

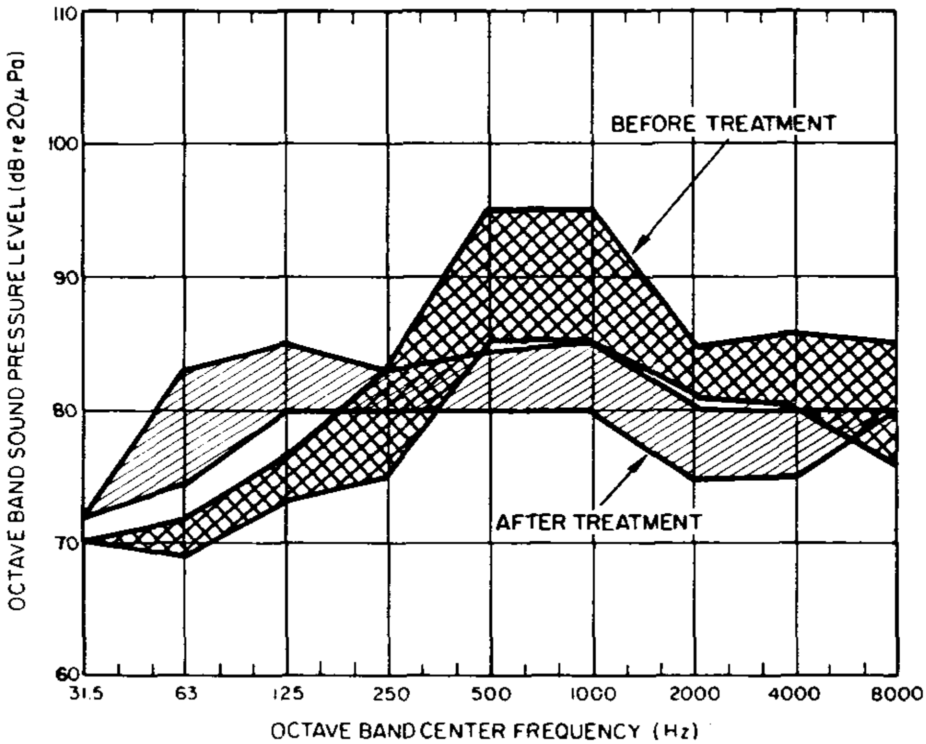

Figure 6.7.1. Plastics grinder; range of sound pressure levels before and after treatment.