## CASE HISTORY 8: HOPPER NOISE (OSHA Noise Problem)

Elliott H. Berger
E-A-R® Corporation
7911 Zionsville Road
Indianapolis, Indiana 46268
(317) 293-1111

This case history describes noise control efforts for a source of industrial noise common to many industries – that of assembly components being dropped into steel plate hoppers.

### Problem Description

The hoppers in this case were open-topped and a little over 63 in. long × 40 in. wide × 21 in. high on one long side, sloping down to 38 in. high on the other long side. Hopper panels are 1/4-in. steel, except for the lower 17 in. of the widest long side, where 1/2-in. steel doors are employed to enable an operator to remove parts. The operator works at a product assembly station positioned between two hoppers, each of which is a meter away from the operator's ears. In this case, the project sponsor sought to reduce the operator noise exposure, although no specific noise reduction objective was stated.

### Problem Analysis

The hopper noise, clearly associated with impacts of metal parts onto the hopper surfaces, can only be generated by hopper metals and assembly parts being set into vibration for the force of the impacts. The E-A-R® Corporation, a manufacturer of damping materials, was called upon to evaluate the potential benefit of treating the hopper panels with damping materials. The subsequent investigation consisted of making noise measurements on an untreated and a treated hopper. Figure 6.8.1 shows the time history of the untreated hopper noise at the operator's position. Here, the unweighted sound pressure is displayed, and the pen tracing corresponds approximately to what a sound level meter set to fast response would indicate. Because the noise occurrence is brief, tape recordings were made for detailed laboratory analysis. The tape recordings were reduced in a laboratory to obtain narrowband analyses of the noise emissions of the treated and untreated hoppers for purposes of comparison.

### Control Description

Treatment consisted of covering the exterior of one hopper with a layer of 3/16-in. E-A-R® C-2003 damping material that, in turn, was covered with an outer layer of 1/8-in. steel. Bostik adhesive was used to bond the damping material to both steel surfaces. The outer perimeter of the steel cover plate, which

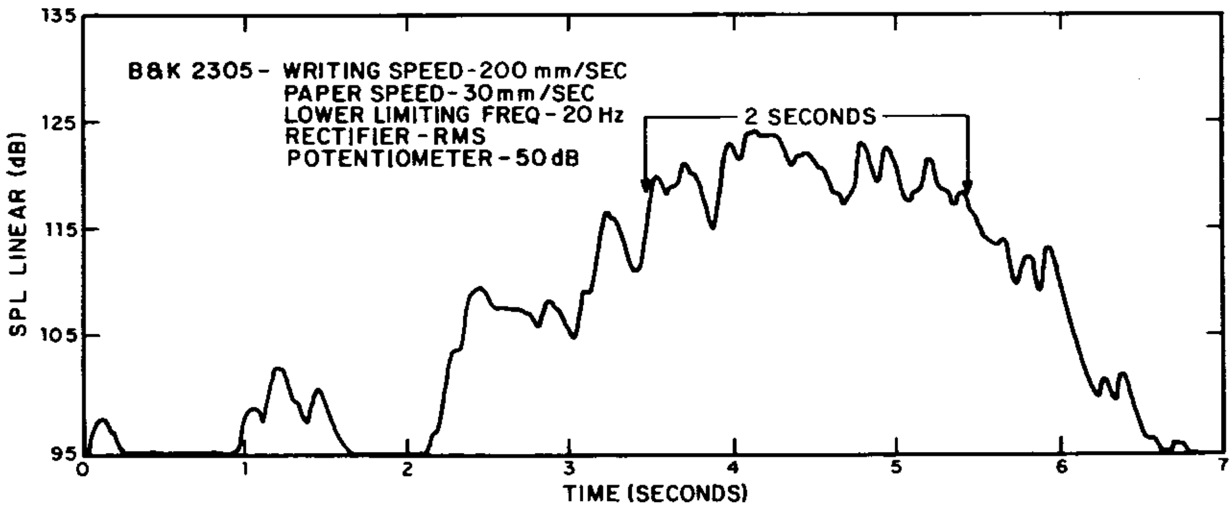


Figure 6.8.1. Overall sound pressure level vs time of noise caused by parts falling into undamped hopper No. 10471.

slightly overhung the damping layer, was welded around the edges to the base plate. The entire sandwich-like treatment constituted what is called a constrained layer damping system – an efficient system for dissipating vibrational energy. One side of the hopper – the side with the door – was left entirely untreated.

Results

Measured noise reduction varied according to frequency but amounted to a 9-dB reduction of the sound level – from 122 dBA to 113 dBA during the 2-sec interval of maximum noise output. Figure 6.8.2 shows the reductions obtained in 1/3-octave bands. The measured reduction is limited mainly by sounds of vibrating parts escaping into the area from the open hopper top.

Comments

Application of sheets of damping material constrained by an outer layer similar to the base structure material can be an effective noise control in numerous other situations where products strike structures and excite vibrations. For example, products are

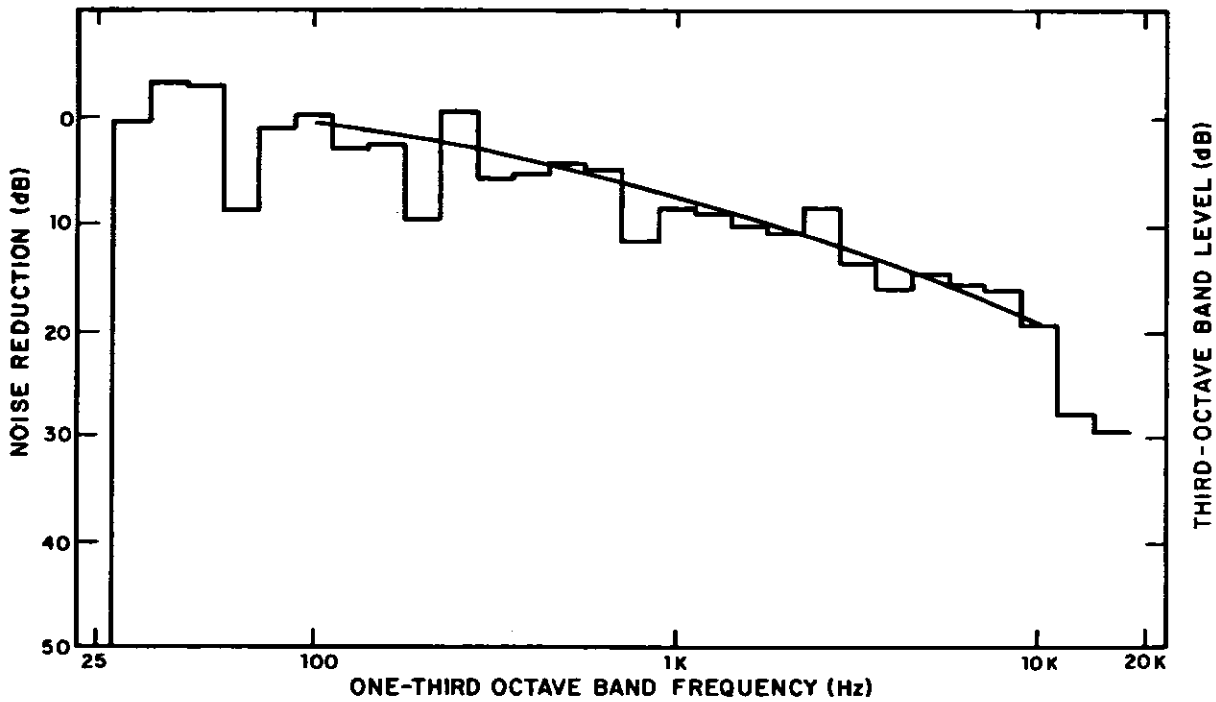


Figure 6.8.2. Noise reduction from damping.

often transported through plants by conveyors. Sheet metal deflectors, bucket elevators, chutes, and other components of the conveyance system are likely candidates for damping treatments.

Extensional damping, where the damping material is bonded to the base structure but is not covered by a constraining layer, may also be effective and is simpler to apply. More damping material would be required, however, and the damping material would be left exposed (a possible source of concern to industries such as food processors).*

Noise reduction obtainable by such treatment can be predicted by measurement of the "loss factor" of the untreated surface and by estimation of the "loss factor" of the treated surface. The former is accomplished by measuring the decay in acceleration levels of the noise-radiating surface and the latter by using the treated surface materials' dynamic properties and the appropriate theory.

Other treatments that might have equal benefit to damping in special situations include:

- Minimizing the force of impacts by reducing free-fall distance of the parts causing impact;

*Generally, a layer of damping material at least as thick as the base structure is used.

- Minimizing the force of impacts by "padding" the struck surfaces, wear factors permitting;
- Reducing the noise-radiating area of the impacted structure, e.g., by using perforated or expanded sheet metal instead of solid sheets.

Damping materials alter the after-the-fact vibrational response of a system to an externally applied force. Thus, application of damping material will reduce the tendency of a surface to ring after it is struck or will retard the propagation of a disturbance travelling away from its point of origin. Damping materials are useful in quieting the ringing of impacted surfaces or in minimizing the area of noise radiation. Note, however, that damping materials have only a small effect on the during-the-fact vibrations response of a system to an externally applied force. If, then, your noise problem is caused by a "forced" vibration of a surface (e.g., vibration of a pipe wall caused by turbulence of the contained fluid), damping materials are inappropriate as a remedy and you should look for other ways to ameliorate the problem (e.g., improve the transmission loss of the pipe wall by wrapping it) (pp. 68-69).

## CASE HISTORY 9: ELECTRIC-POWERED TOWING MACHINE (OSHA Noise Problem)

Robert C. Niles
Uniroyal, Inc.
Oxford Management and Research Center
Middlebury, Connecticut 06749
(203) 573-2000

### Problem Description

At the Uniroyal tire manufacturing facility, in Opelika, Alabama, noise to which a "Green Tire Truck Tugger" operator is exposed was measured and found excessive under OSHA regulations. The employee operates a "stand-up" electric-powered towing machine that moves green tires from the tire building machines to the spray machine and returns with empty trucks from the curing process.

### Problem Analysis

The problem is the noise caused by hauling the empty trucks. The "truck" that carries the tires consists of a metal frame with hollow metal elliptical prongs that hold the green tires (Figure 6.9.1). When the "truck" is empty, the prongs vibrate and act like a sounding drum, emitting a loud noise. The loudest noises occurred on concrete floors because of unevenness caused by globs of rubber on the floor. Metal plate aisles were quieter.

Noise at the operator's ear measured 100 dBA when he was towing the empty trucks — a sound level that exceeds the OSHA allowable limit. In addition to the operator exposure, adjacent employees are subjected without warning to a loud intermittent noise, which is motivationally depressant.

### Control Description

The prongs were filled with a rigid foam, developed by Rubicon at Naugatuck through the cooperation of Mr. Thomas Haggerty. It is an MDI, polyurethane foam, formula RIA Nos. 553A and 553B. The product is shipped as liquid foam in two parts, which are combined on the job. Cost is estimated at about $1 per kilogram, depending upon quantity and comes to about $10 per truck. As a company, Uniroyal does not furnish the material directly. For the supplier nearest the use point, please contact Mr. Thomas Haggerty at the Uniroyal Naugatuck Plant, Phone: (203) 729-5241, extension 225. The formula is fireproof and nontoxic.

### Results

The original and after-treatment noise data were taken by riding the tugger next to the operator. Both sets of data were taken in

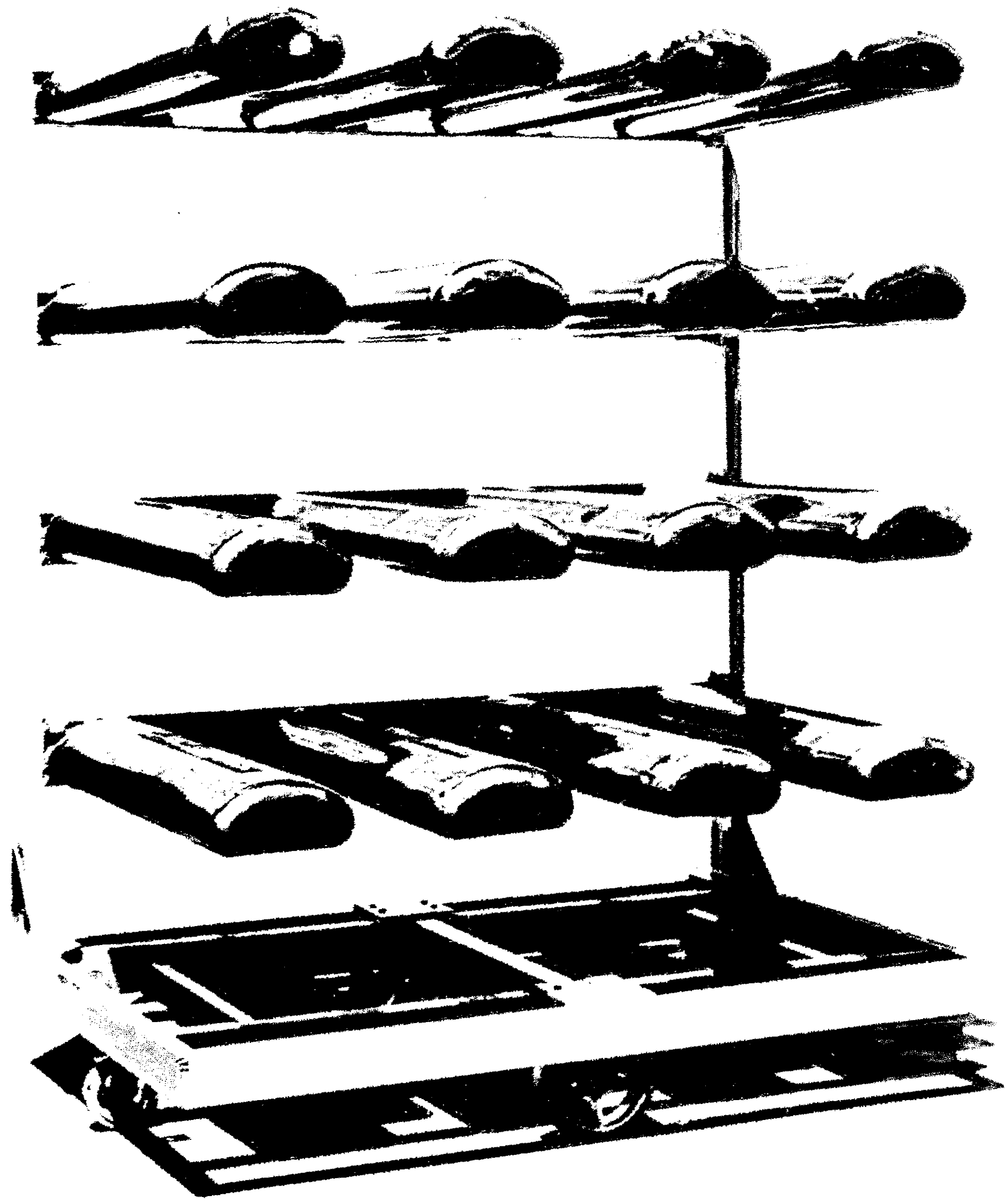

Figure 6.9.1. Green tire storage truck.

a warehouse in order to ensure low ambient noise conditions. The same tugger, same route, and ambient sound levels were used for both the "before" and "after" tests.

The noise abatement program of filling the prongs with a rigid foam resulted in a 10-dB reduction, adequate to alleviate the noise problem as defined by OSHA.

CASE HISTORY 10: BLANKING PRESS
(OSHA Noise Problem)

Problem Description

In forming operations, large blanking presses are used. The ram, which is like a connecting rod in a reciprocating engine, is hollow. The forming die runs in grooves on the side of the press, like a piston in the cylinder of a reciprocating engine, and completely closes off the end of the hollow ram. There are slots in the ram that are used normally when the press is used in blanking operations to extricate the work from the die, similar to removal of a cookie from a cookie cutter. These slots are in the side of the ram (see Figure 6.10.1). When the press is

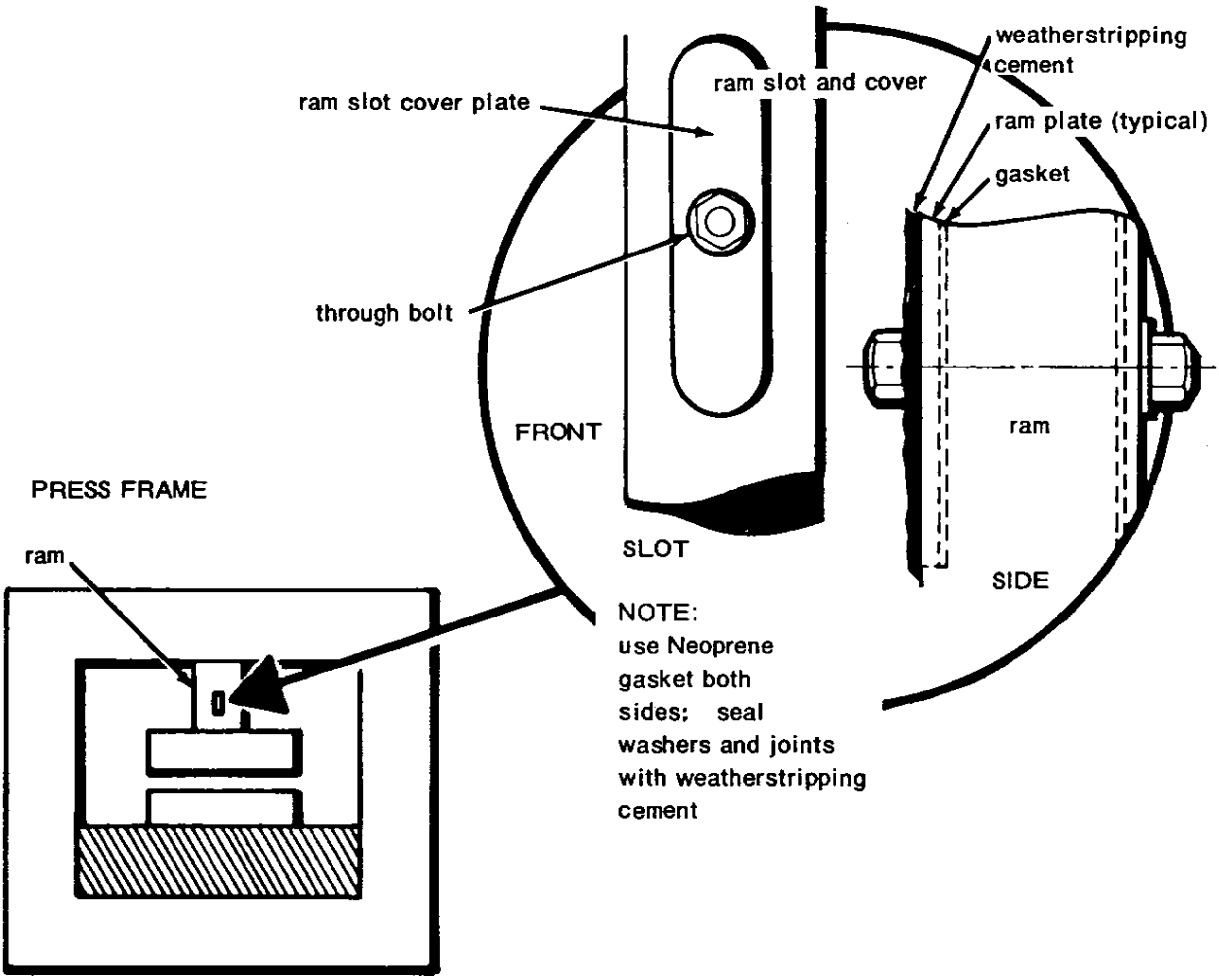


Figure 6.10.1. Method used to cover slots in blanking press ram.

being used in the forming mode, these slots are not required, and when the die "snaps through," it cuts off the work. This gives rise to high sound levels.

Problem Analysis

In a vibration-isolated forming press, operator position sound levels were $L_A$ = 94 dBA, $L_C$ = 100 dBC in the "slow" reading position. An octave-band measurement disclosed that sound pressure levels in the 250-, 500-, 1000-, and 2000-Hz bands were much higher than in other bands. This ringing noise, which had a maximum near 2 kHz, was easily discernible by ear. By careful listening, it was determined that the source was radiation from the slots in the ram.

The technical conclusion was that the hollow ram interior, with the slots, was essentially behaving as a shock-excited Helmholtz resonator. A Helmholtz resonator is a closed volume of air connected by a tube to the outside air; it resonates at various frequencies (as when air is blown across a glass jug opening).

The one approach that would obviously work would be to fill the cavity in the ram with rubber-like material. Another approach would be simply to plug the slots, thus keeping the noise inside the ram. The second approach was chosen because it was easy to try, inexpensive to test, and allowed the machine to be re-converted easily to a blanking operation.

Control Description

The ram slots were each covered with a plywood plate sealed with a Neoprene gasket, as shown in Figure 6.10.1. Weatherstripping (nonhardening sealant) was used to prevent small leaks. These control measures were easily installed.

Results

The first attempt was satisfactory and achieved a 6-dB reduction of quasi-peak sound level from 99 to 93 dBA. See Figure 6.10.2. Applying this to the observed slow A-reading of 95 dBA yields the observed 88 dBA.

This case history demonstrates both the simplicity (the solution) and the complexity (the resonator) of noise control. It also demonstrates a more subtle feature: Simple solutions are worth trying if there is a good physical reason for them.

Comments

The obvious pitfall here would be to apply this solution to a press that had not first been vibration-isolated. If the press

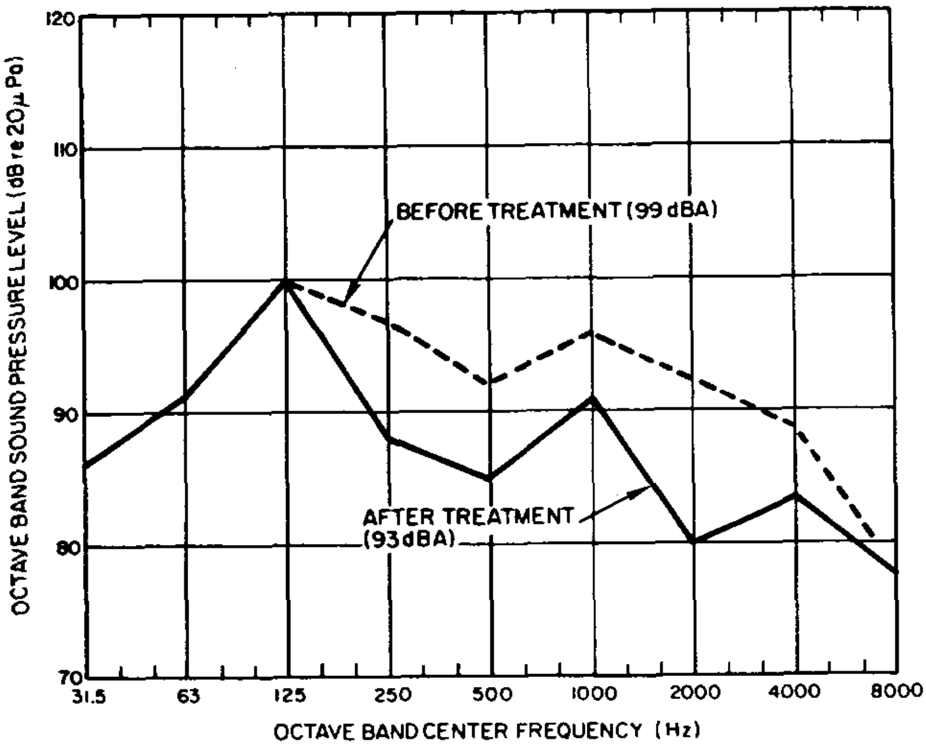


Figure 6.10.2. Quasi-peak readings of blanking press after ram ringing was contained.

were on other than piers isolated from the building, or had sheet metal guards, one would probably not have been able to measure any improvement. Filling the ram cavity would have been another pitfall. It would have accomplished the noise reduction, but would have prevented easy reconversion of the press to blanking operation.

CASE HISTORY 11: SPINNING FRAME
(OSHA Noise Problem)

Problem Description

Cord manufacturers use a machine called a spinning frame to convert yarn to cord. In the process of spinning this yarn into cord or thread, lint or small pieces of yarn fall away. At each spinning station along the frame, air suction removes this lint by a system that works essentially like a vacuum cleaner. This system requires a rather large air-moving system for each spinning frame, and the noise created by these air-moving systems causes the ambient sound levels to range from 88 to 93 dBA at the work stations throughout this system. This unit was a Whitins Model M-2.

Problem Analysis

Measurements were made with a Type 2 sound level meter. At about 1 in. from the air exhaust of the lint scavenger system, the sound levels were: $L_A$ = 100 dBA, $L_C$ = 100 dBC. The major noise source was unquestionably the air escaping from the lint removal system, as was verified by the fact that $L_A = L_C$. This problem is common in high-velocity air systems.

Control Description

The obvious solution to a problem of this nature is to use a muffler or an acoustical isolator. However, a more fundamental approach considered was to slow the escaping air at the scavenger exhaust. This slowing could be accomplished by simply giving the exhaust vent a bigger open area, as shown in Figure 6.11.1. The velocity of the escaping air was estimated to be 115 ft/sec (the fan moved 1800 cfm through an area of about 37 in.$^2$). Simply to open the fan cover was not practical, since the air must be directed upward.

The reason this control approach is a good one to consider can be best summarized in the following relationship:

$$X = 10 \log_{10} (V_0/V_n)^5 ,$$

where X is the reduction in decibels, $V_0$ is the original air velocity, and $V_n$ is the new air velocity.

This equation is widely used by noise control engineers to estimate the relative noise reduction if air stream slowdown is possible.

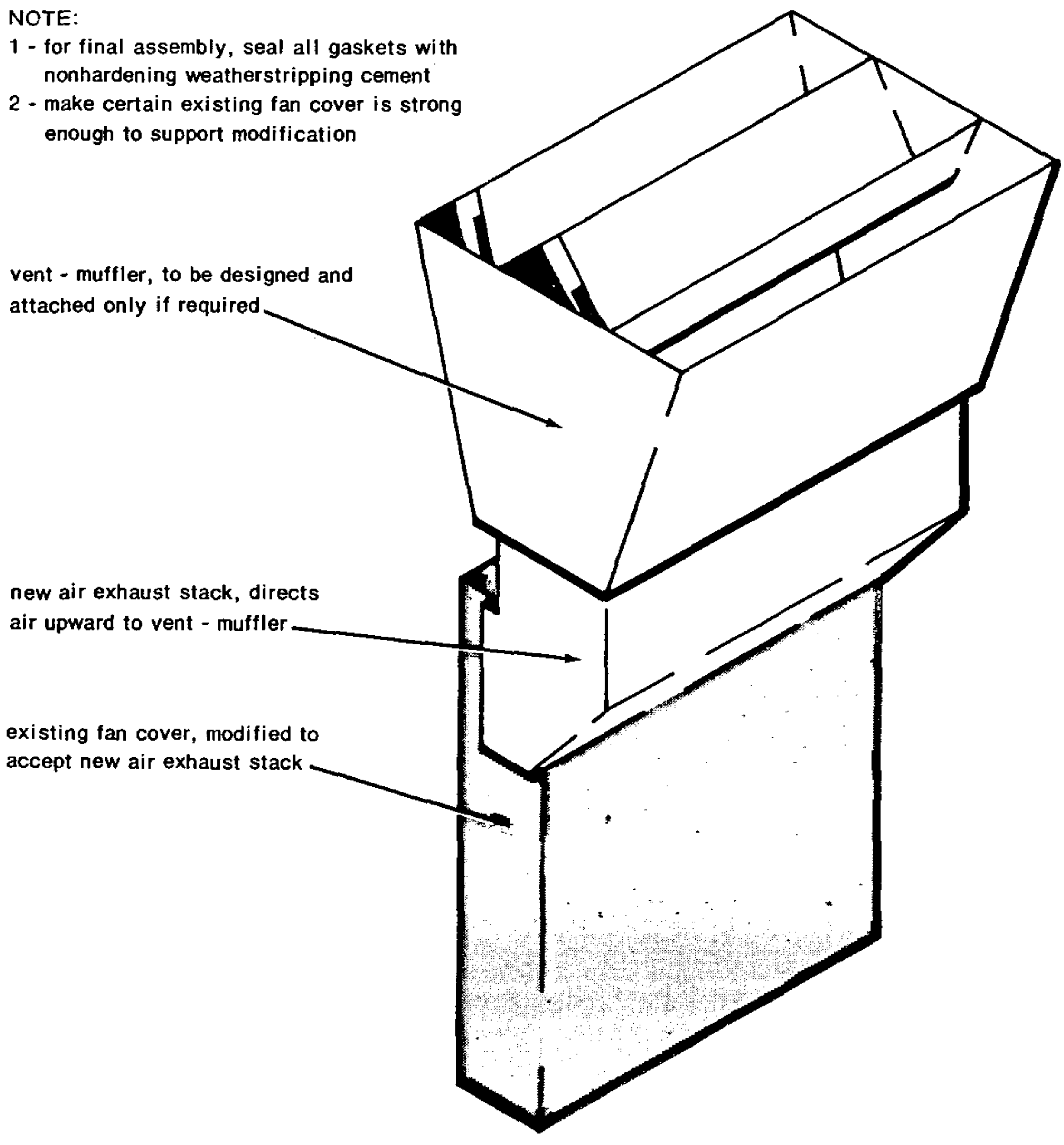


Figure 6.11.1. Air exhaust vent modification for spinning machine noise control.

The design increased the area through which the air exhausted by a factor of 10: from 0.26 $ft^2$ to 2.6 $ft^2$. Because the flow is practically imcompressible, $V_0/V_n = 10^{-1}$ and X = 50 dB reduction. However, the net noise reduction will ordinarily be less because other noise sources are still present. A rule-of-thumb is to expect a useful reduction of, at most, 10 dB if a major source is completed removed. The chief exception to this rule is the intense and often high-frequency pure-tone single source, such as a whistle, steam vent, or automatic control valve.

Results

The noise was measured, with all but one fan cover unchanged; it was $L_A$ = 93 dBA and $L_C$ = 94 dBC, a reduction of 7 dB. It is thought that this reduction fairly well represents the background level without this fan running.

Comments

The most common pitfall in a treatment of this kind is to attempt to do a makeshift or sloppy final job. Care must be taken for the final result to be effective. A professional metal shop can fabricate the device shown in Figure 6.11.1 easily, in quantity, and possibly less expensively than it could be fabricated in your plant. The rubber gaskets and sealant are both important to the overall effectiveness of the job.

CASE HISTORY 12: BOXBOARD SHEETER
(OSHA Noise Problem)

Problem Description

The sheeter, starting from large rolls of boxboard about 6 ft in diameter, cuts the web to length with a rotary knife that can be adjusted to rotary speed, and therefore sheet length, by means of variable speed drive (Reeves Drive). The cut sheets are delivered to pallet. The speed is about 700 ft/min.

Problem Analysis

At the operator control station near the sheeter (see Figure 6.12.1), the sound level was found to be 93 dBA. Close-in probe

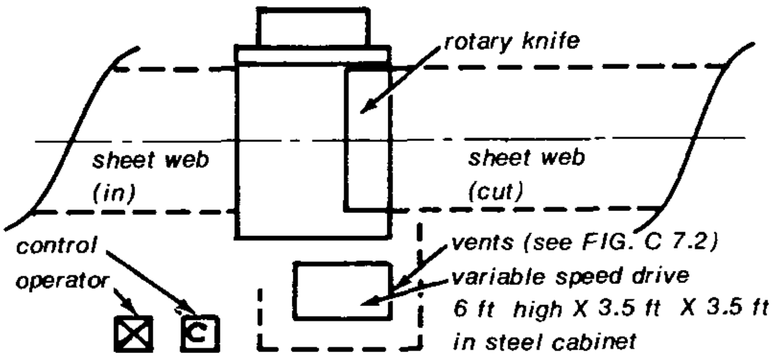


Figure 6.12.1. Floorplan of sheeter for boxboard.

readings at the variable speed drive were high, indicating that the drive is a major noise source. Readings were as follows:

96 dBA close to front drive guard, in aisle

98 dBA close to front drive guard, in aisle 3

105–107 dBA close to front drive vent openings.

The drive box enclosure was a steel shell 6 ft high, 3.5 ft wide, and 3.5 ft deep, having two vent openings in the side for natural air cooling (see Figure 6.12.2).

Other operator locations that were far from the drive were checked:

90 dBA: operator at delivery

88 dBA: operator at rollstand in feed (see Figure 6.12.3 for general layout).

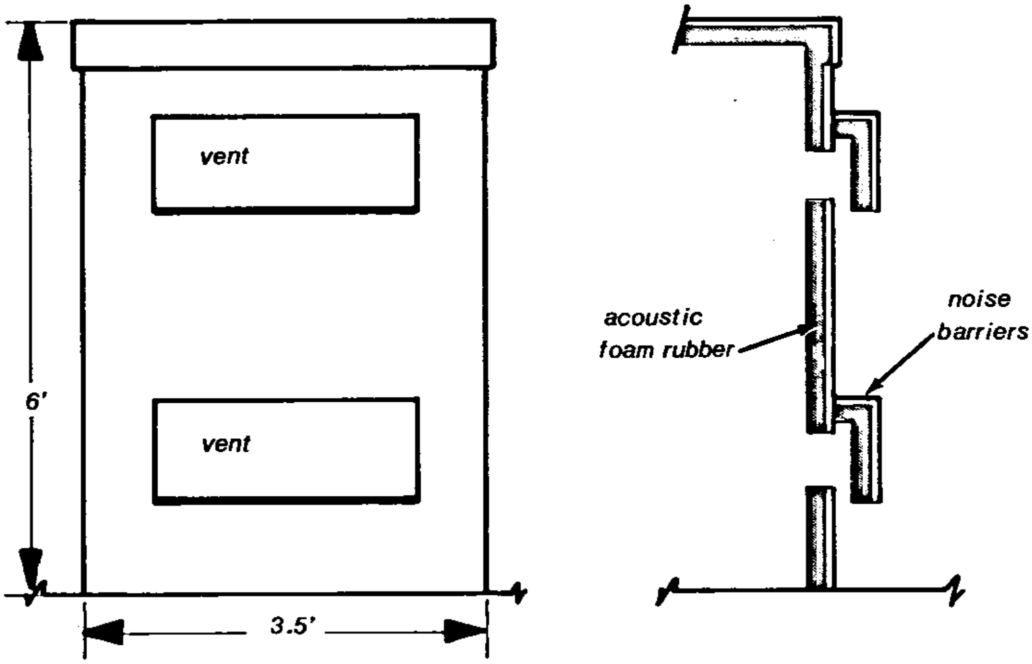


Figure 6.12.2. Sheeter drive box enclosure.

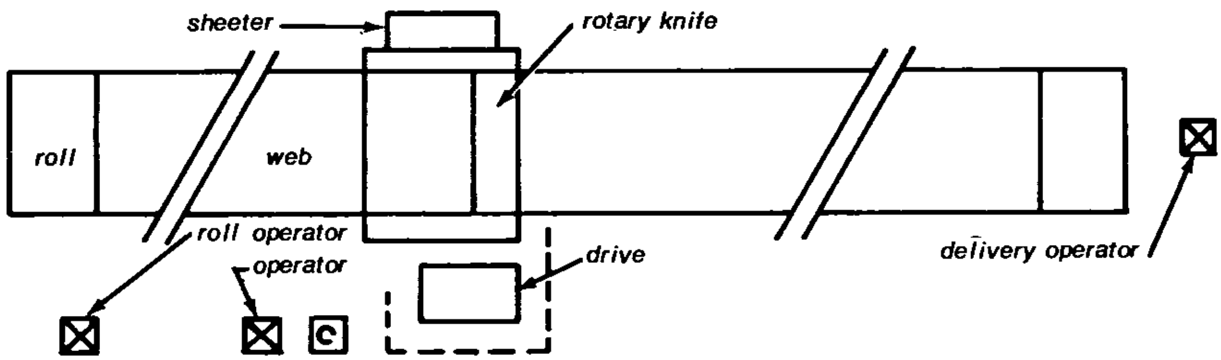


Figure 6.12.3. Layout of sheeter and operators.

From the close-in readings, the drive was determined to be the major noise source and not the roll unwind stands, rotary cutter, or delivery belts to finished pallet of boxboard.

Control Description

To reduce the drive noise within the steel box enclosure, it was decided to line the interior walls with an acoustic absorbing polyurethane foam with a layer of 0.017-in.-thick sheet lead to provide damping of the steel surface panels. To reduce the noise coming out of the air vents, an acoustic trap was designed to absorb the noise at the vents but allow full normal air circulation. This acoustic trap is shown in Figure 6.12.2.

Results

The sound level at the operator control panel near the drive unit was found to be 89 dBA, reduced from 93 dBA. In addition, some reduction was obtained in other operator positions:

86–87 from 90 dBA, operator at delivery

86 dBA from 88 dBA, operator at roll stand.

Sound levels close-in to the vents were reduced to 94 dBA from 105 dBA; this is not an operator position.

Sound-absorbing polyurethane foam with a lead septum designed for combined damping and absorption is available from various suppliers at less than $4/ft; material cost was about $400, and in-house labor to glue in place and fabricate a holder for the sound trap was about another $400; total cost was about $800.

Comments

Without close-in reading to locate the drive unit as the major noise source, the conclusion could have been that the entire sheeter, including the drive unit, must be installed in an acoustic enclosure, and a great deal more money would have been spent for the solution.

This kind of noise reduction is typically not as satisfactory as one would like. The major problem that can arise is the existence of other direct sound paths from the knives to the operator.

Another pitfall for sheeters is the knife design. Some of the older models have straight knives instead of an angular striking or cutting edge. Straight knife sheeters will probably require an acoustic-absorbent-lined metal or wood hood over the knife assembly and perhaps under the knife assembly.

## CASE HISTORY 13: CARDING MACHINES (OSHA Noise Problem)

Rene Boisvert
Biddeford Textile Company
2 Main Street
Biddeford, Maine 04005
(207) 282-3376

### Problem Description

Carding machines are used in the textile industry in the process of making thread from bulk cotton or wool. The cleaned raw material is fed into the carding machine, which first combs the material to orient the fibers properly, forming a weak sheet of material in the process. The sheet is then condensed into filament form by the action of close-fitting, horizontal counter-reciprocating beds called aprons.

It is the mechanism driving the aprons that causes the noise problem here: A vertical eccentric drive shaft moves the several tiers of aprons back and forth, much as the crankshaft of an automobile engine drives pistons back and forth. In this case, however, there are numerous mechanical impacts – all making noise – that occur at the linkages and supports between the drive-shaft and the aprons, where metal washers are employed as spacer elements. Operators work all around the carding machines, each operator tending several, making sure they function smoothly, supplying raw material, removing product, and keeping the area clean.

### Problem Analysis

Analysis of the time history of individual operator noise exposures revealed (1) that OSHA time-weighted noise exposures were marginally exceeding allowable limits and (2) that the greater part of the noise exposure occurred at the discharge ends, where sound levels range from about 91 dBA at mid-aisle positions to about 96 dBA at operator positions nearest the drive-shafts. Noise conditions there were audibly dominated by the mechanical clacking at the apron drive mechanism. Close-in to the drive mechanism, sound pressure levels, shown and compared with mid-aisle data and a 90-dBA criterion curve in Figure 6.13.1, verified that conclusion. Although sheet metal guarding, providing physical protection from the drive mechanism, surrounded three sides of the drive, the guarding provided little in the way of containment of the clacking sounds; most of the sound energy simply reflected from the guard surfaces and thence contributed to the reverberant sound field (near the

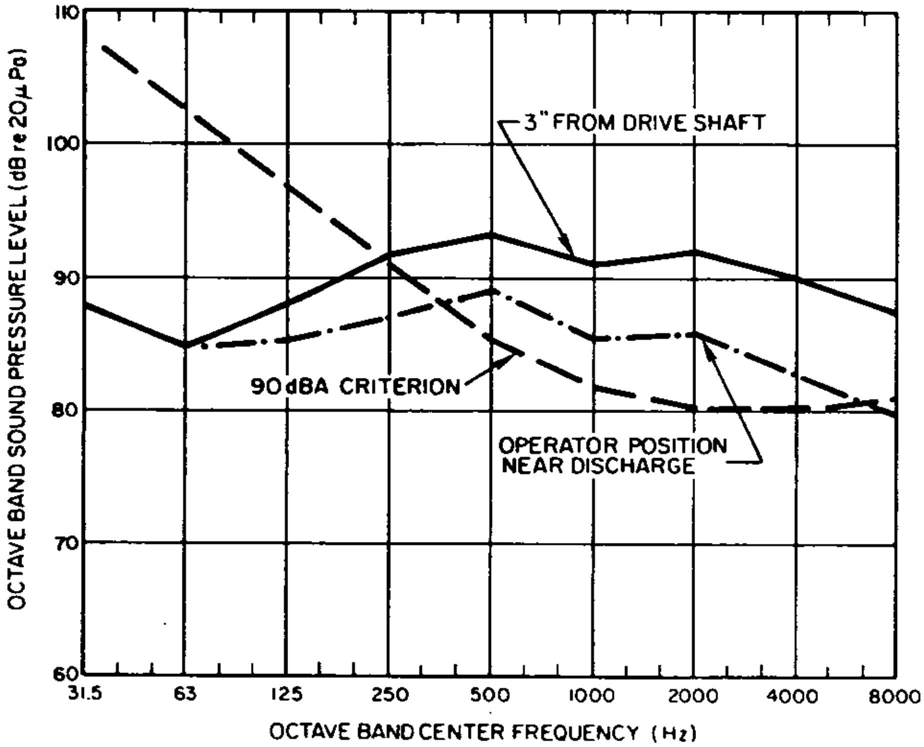


Figure 6.13.1. Sound pressure levels at carding machines.

guarding and on the operator's side, the sheet metal acted as a sound shield, but it is the reverberant energy that is important here).

Although a quieter drive mechanism might have been developed, Biddeford Textile also knew that the original equipment spacers provided much quieter machine operation. The problem was that the original equipment spacers were no longer available. Biddeford Textile opted for finding a suitable softer replacement washer. After experimenting with nylon and Teflon washers that did not stand up to service requirements, the company found a fiber washer available from B&S Machine Co., 2420 N. Chester St., Gastonia, NC 28052, (704) 864-6796, that provided the necessary properties.

Results

Sound levels at operator positions nearest the driveshaft after installation of the fiber washers are now no higher than 87 dBA, and operator noise exposures are well within OSHA-stipulated limits.