

CASE HISTORY 35: CONCRETE BLOCK-MAKING MACHINES
(OSHA Noise Problem)

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This case history compares four separately designed and installed enclosures for concrete block-making machines from the standpoint of acoustical performance, maintenance, and production. This work illustrates several important considerations in enclosure design.

Problem Description

Figure 6.35.1 shows a typical mechanical block machine. The machine accepts raw material in the form of water, binder, sand, etc. from a hopper above the machine and forces it into a mold while the molding is vibrating, until the mixture is of the proper

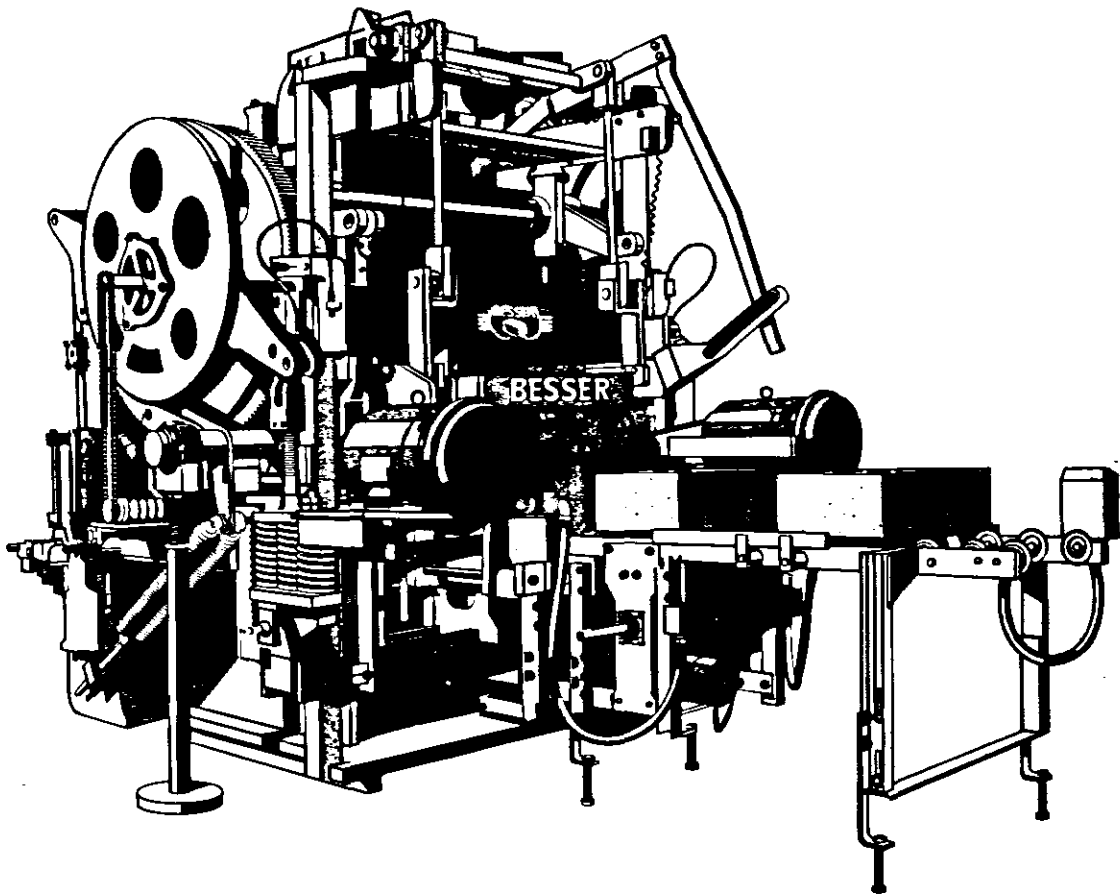


Figure 6.35.1. Typical concrete block manufacturing machine.

volume and consistency. The mold is then withdrawn, and the finished concrete block leaves the machine.

The blocks are formed on 1/4-in.-thick steel rectangular pallets that transport the uncured blocks to a rack system, by which they are stacked for curing and later storage. Depending on the operation of the facility, the blocks and pallets are carried to curing kilns by either automated or manual* transfer. After a sufficient time, the blocks and pallets are removed from the kilns and placed on another rack system. This system separates the blocks from the pallets, returning the pallets to the machine to be cleaned and reused for new blocks, while sending the blocks to the cubing area, where they are stacked for yard storage and eventual use in construction. Figure 6.35.2 shows the typical material flow paths for a block machine. If there is more than one machine in a plant, each machine has its own similar material flow path.

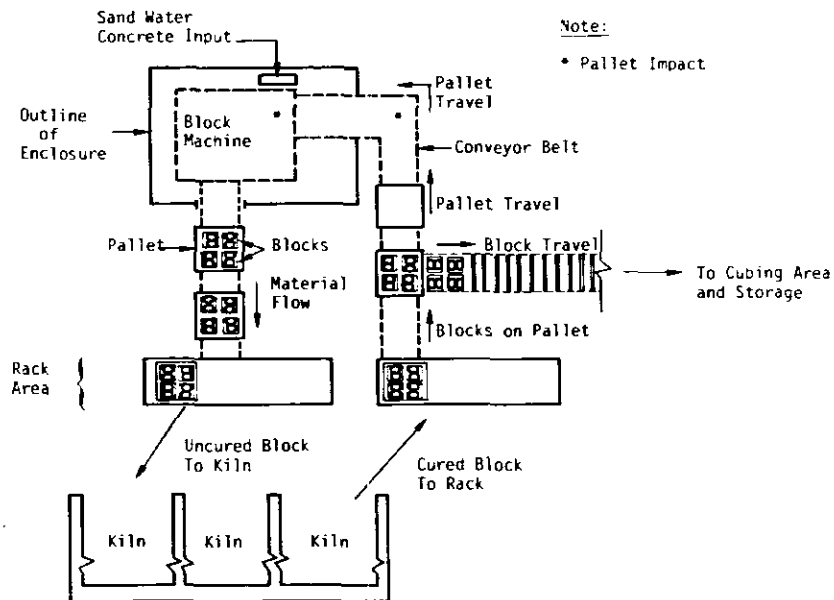


Figure 6.35.2. Typical concrete block plant material flow plan.

Operators work close to their machines to observe the machine functions and to make quick corrections as needed and, usually, because the control panel is integral to the machine. Operators' noise exposure is governed by the following sources:

*Usually by a forklift truck.

(1) The vibrations operations mode: Eccentric weights, attached to the mold, vibrate the mold to provide the proper compaction of the concrete mix. The mold vibrates against the steel pallets and produces cyclical sound levels with a maximum of about 115 dBA measured at about a meter from the mold. The vibration mode occurs only when the mix is being molded. As the block leaves the machine, the vibration ceases. Vibration lasts for about 6 sec during each 10-sec cycle. The timing of the cycling is highly dependent on the operating condition and production of the machine.

(2) The pallet cleaning operation: As the pallets are returned to the machine, an accumulation of dried concrete must be removed from the pallet surface by brushing and scraping the pallet. The frictional force of the scraping blade on the pallet produces a high-pitched noise, clearly audible and probably more annoying than the higher level, broadband vibration noise.

(3) The pallet impact noise: Pallets are stacked within the machine, so that the supply to the block machine is sufficient. When the pallets are returned, they must change direction (usually by a sharp-right-angle, discontinuous conveyor) and stack up. The stack-up and direction change are locations for metal impact. These impact sound levels are relatively high and of short duration. The frequency of impact depends on the production rate.

There are other noise sources in the plant, although they are of minor concern in relation to the block machine. Three common secondary sources are:

(1) The cuber machine, which stacks the blocks mechanically or hydraulically

(2) The hydraulic pumps, which are used to operate the hydraulic block machines

(3) The rack motion, which produces a high-pitched noise caused by friction with the guide rails.

(It should be noted that the block machine enclosure does nothing to reduce these secondary noise sources.)

Problem Analysis

The work reported on here was done as the first phase of an extensive study to determine if enclosures could be effective as a means of noise control for concrete block manufacturing machines. Concrete block manufacturers have recognized that these machines are responsible for OSHA noise overexposures, and thus the work

reported on here did not include any detailed noise source analysis, nor were baseline data reported. However, design considerations were detailed as follows.

Ideally, the acoustical enclosure should be designed to surround the block machine completely. The noise reduction would then depend basically on the material of the enclosure's construction. In practice, at least four enclosure penetrations are required:

- An entrance for raw material input
- A discharge for the block and pallet
- An entrance for the pallet
- Ventilation paths.

This type of machine requires additional constraints in the enclosure design which, in general, subtract from its ideal acoustical performance:

- The major design consideration is safety; the enclosure should not promote any unsafe conditions which may be caused by a worker's inability to see impending danger or by his difficulty in moving away from a hazardous situation.
- To maintain equipment at proper working temperature and to remove possibly toxic fumes, an adequate ventilation system must be provided.
- When the block machines need maintenance and/or overhaul, the enclosure should allow access to the machines with minimum effort.
- As the concrete mix pours into the mold and during molding, the mix falls from various sections of the machine. Hence, the machine and the area in the vicinity of the machine are constantly being sprayed by this concrete mix. This mix builds up and hardens quite rapidly, and it must be removed frequently. Removal is usually by hand, and thus easy access to the machine must be provided for clean-up.

Control Descriptions and Results

Plant 1

Figure 6.35.3 shows the maximum sound level contours produced by the enclosed block machine. The enclosure construction consists of 1/16-in. sheet steel with 1-in. thick to 2-in. thick open-cell foam lining the interior. Single-light, 1/4-in. glass

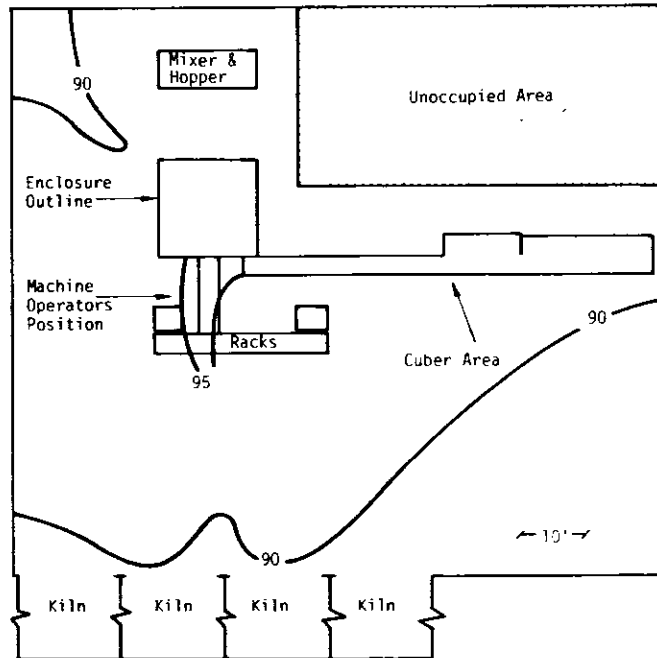


Figure 6.35.3. Plant 1: maximum sound level contours.

is used for the viewing ports. Hard rubber flaps are used as panel gasketing. Doors on two sides provide access without necessitating dismantling of the enclosure, although lack of clearance between the machine and enclosure walls makes working space very tight. By mounting three sides of the enclosure on rollers, the enclosure can be easily opened for machine access and cleaning. However, the easy access offered by this method also allows the enclosure to be damaged easily because it is often opened. Because of the poor fit after much use and also because of the hard-rubber, nonyielding gasket, air leaks exist at almost every joint. Thus, in practice, the enclosure is relatively inefficient compared to its potential acoustical effectiveness. Furthermore, noise "flows" out of the large material entry and exit ports. This leakage is not important in this case, because other leaks are as predominant a flanking path as the material ports.

Although the contours show that the sound level of the plant is, at times, above 90 dBA, the enclosure is effective since the plant personnel exposure does not exceed the OSHA-allowable criterion. The sound levels inside the machine are about 110 to 115 dBA. The cost of the enclosure was \$10,000 to \$12,000* in 1972.

*This cost does not include time for plant personnel, production delays, etc.

Plant 2

Plant 2 has two block machines, and only one machine is enclosed. The enclosure in Plant 2 is constructed of 1/2-in. plywood with an interior surface of 3-1/2-in. loose fill and 2 1/2 in. of glass fiber batting. The windows are gasketed Plexiglas. The total enclosure cost about \$15,000* in 1973. Figure 6.35.4 shows the A-weighted sound level contours with the only enclosed block machine in operation.

Acoustically, the enclosure is effective although very inefficient. The noise reduction could be significantly increased if the access doors were gasketed. Further improvements can be gained by providing acoustically lined ducts for block/pallet output and pallet input. Practically, however, the enclosure is unsatisfactory; accessibility to the machine is difficult, heat build-up is high, the Plexiglas windows are so scratched that they are almost opaque, cull (scrap) production has increased, and production has decreased significantly. The heat build-up is so high the enclosure door is left open to ensure adequate ventilation. These drawbacks led management to the decision not to enclose the second machine until a better enclosure (or other means of reducing employee noise exposure) is

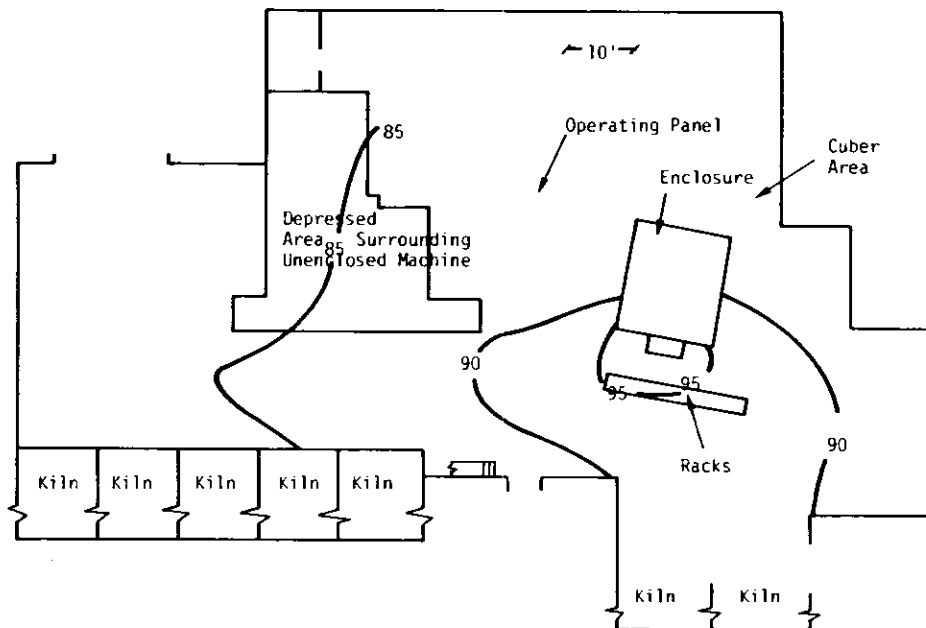


Figure 6.35.4. Plant 2: maximum sound level contours.

*This cost does not include time for plant personnel, production delays, etc.

designed. Figure 6.35.5 shows the contours with both machines operating. The operation of the unenclosed machine makes the enclosure completely ineffective except at the cuber area, where the enclosure acts as a noise barrier.

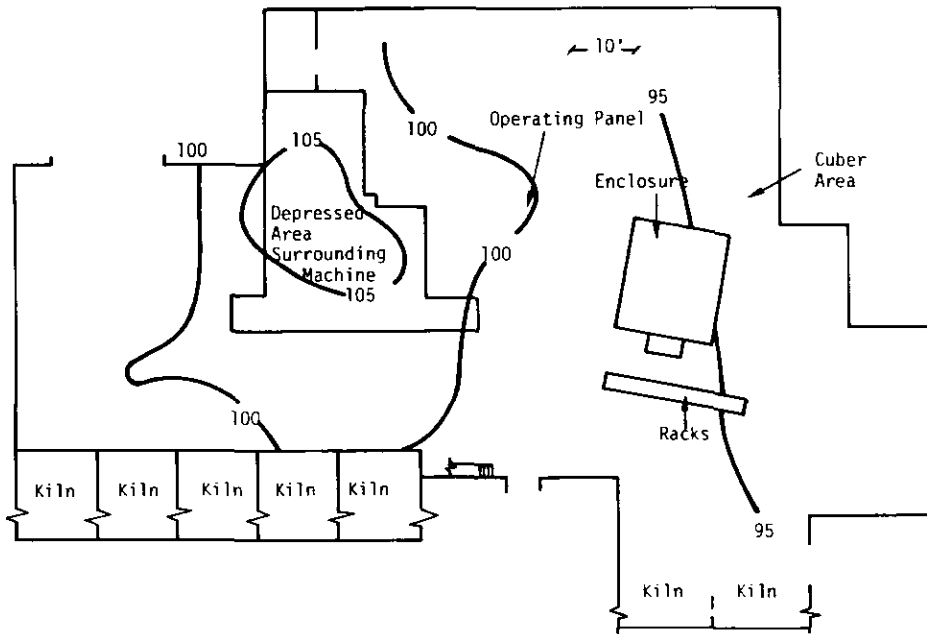


Figure 6.35.5. Plant 2: maximum sound level contours (enclosed machine operating).

Plant 3

This plant has a hydraulic block machine. The enclosure consisted of 1/16-in. sheet steel with 1/4-in. foam/1-lb/ft² sheet lead/1-in. foam interior. The doors are well gasketed and sealed with refrigerator-type locks. The five viewing ports are double-light (1/8-in. glass/approximately 3-in. airspace/1/8-in. glass), well-gasketed glass. Although there are penetrations of the enclosure, the small clearances between the material and the enclosure shell provide minimum noise leakage. The heat build-up problem is reduced by the addition of a 21,000-BTU air conditioner. The enclosure cost between \$20,000 and \$40,000* in 1973.

*This cost does not include time for plant personnel, production delays, etc.

The hydraulic pumps used to power the block machine are away from the machine and are partially enclosed with a plywood and lead/foam-lined shell which extends over the top and halfway down the sides.

Figure 6.35.6 shows the maximum sound level contours in the plant. This is an acoustically effective enclosure. In addition, employees have only minor problems in day-to-day operation of the machine with the enclosure. Access doors to the machine and clearance inside allow two or three people in the enclosure to repair or adjust the machine. Clean-up also is relatively simple.

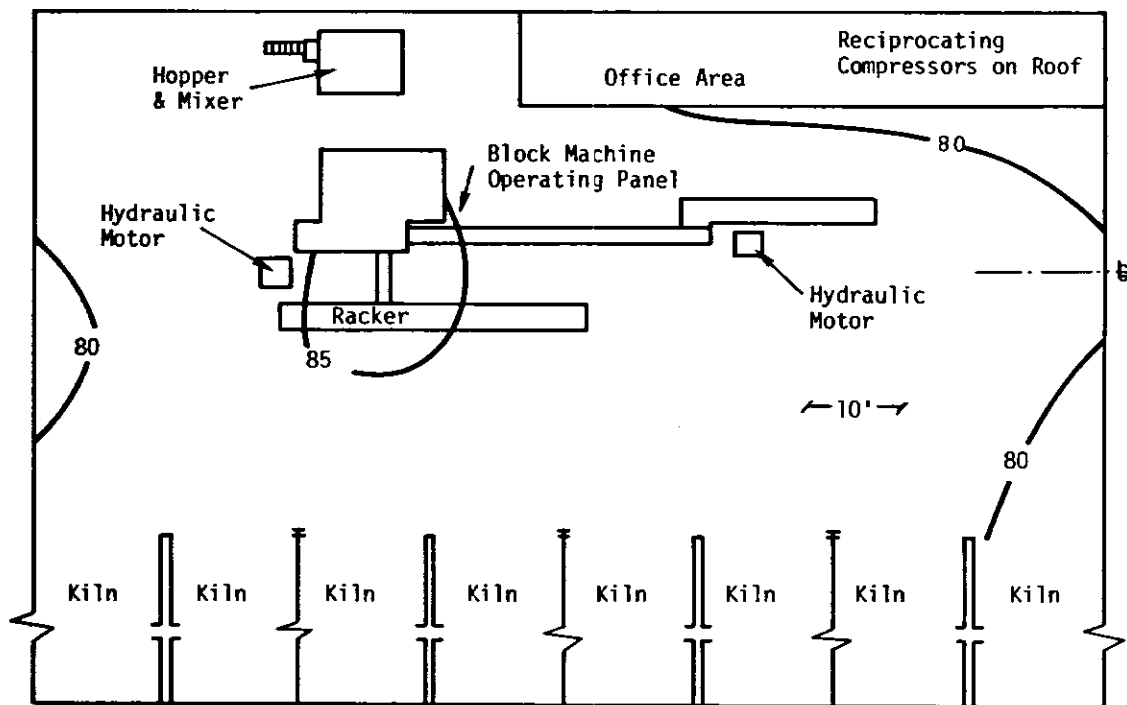


Figure 6.35.6. Plant 3: maximum sound level contours.

Plant 4

Plant 4 has two enclosed mechanical block machines. Both enclosures consist of 1/16-in.-thick sheet steel with interior surfaces lined with 1/4-in. foam/1-lb/ft² sheet lead/1-lb foam. The small viewing ports are gasketed Plexiglas and are used only for adjusting the timing of the machine. The sides and front

slide up on guide rails to provide machine access and allow for clean-up and mold change. Double gasketing is used throughout. The clearances between the material and the enclosure are small at each enclosure penetration. In addition, the block/pallet exit port consists of a small lined duct. Each enclosure cost approximately \$30,000* in 1973.

Figure 6.35.7 shows the maximum sound levels produced during the vibration cycle with one enclosed machine operating. In this plant, there are other major noise sources: bin vibrators and pallet impacts. Figure 6.35.7 also shows sound levels, at selected locations in the plant, caused by the bin vibrator. Figure 6.35.8 shows a detail of the operator's station. The increase in sound levels from the other noise sources is noted and is apparent.

The employees felt the enclosure was beneficial: It did not decrease production and made the plant significantly quieter.

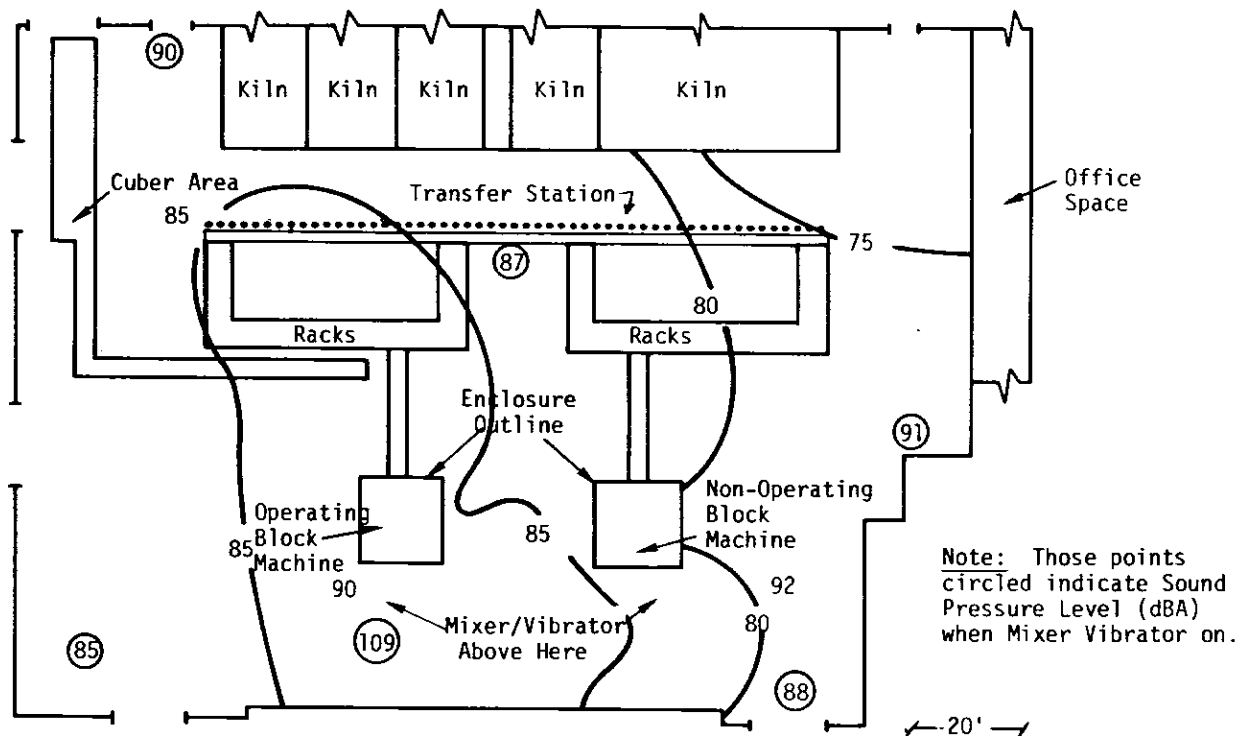


Figure 6.35.7. Plant 4: maximum sound level contours.

*This cost does not include time for plant personnel, production delays, etc.

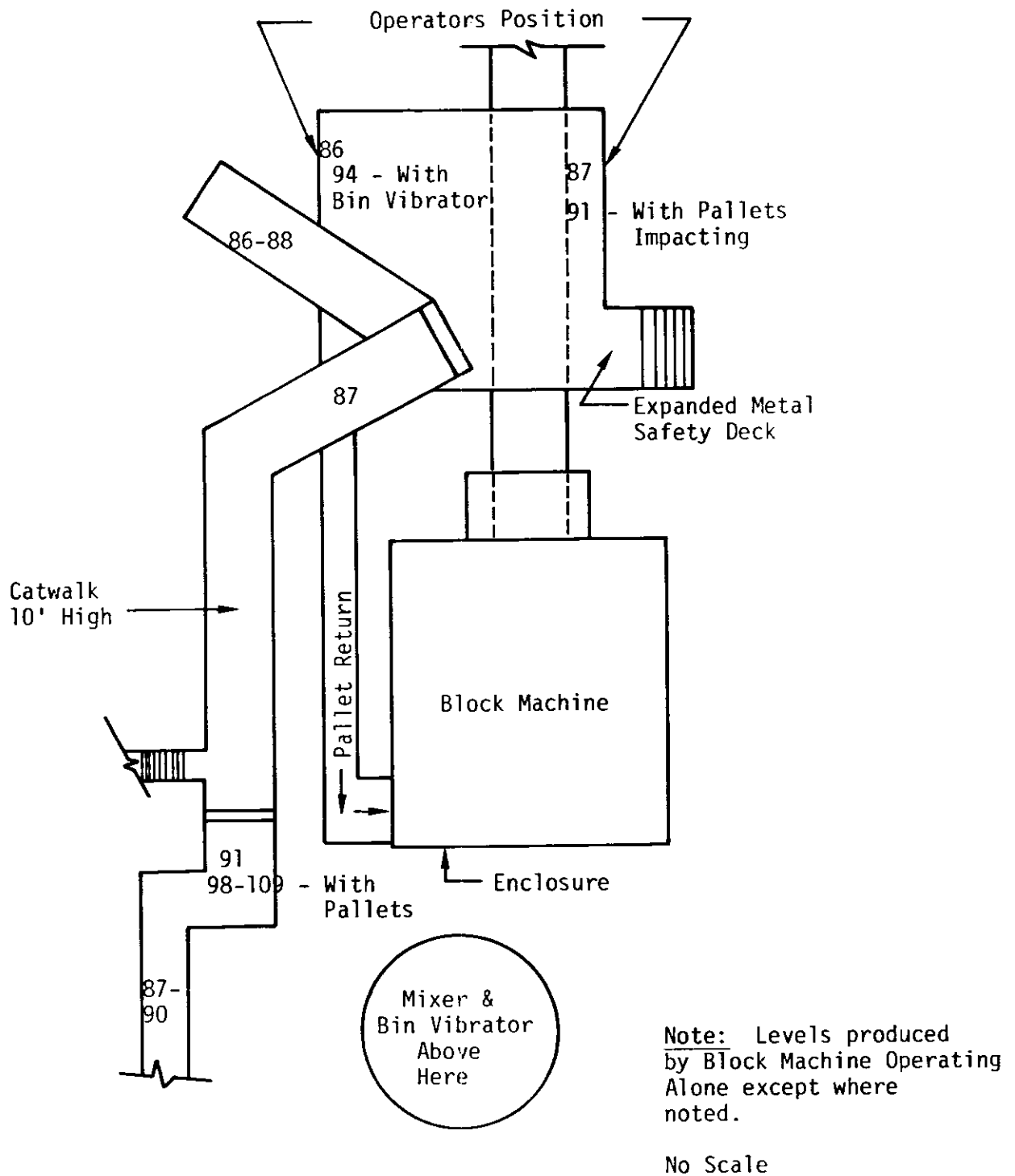


Figure 6.35.8. Detail of operator's position and maximum sound levels.

CASE HISTORY 36: JORDAN REFINERS
(OSHA Noise Problem)

Problem Description

In a boxboard waste paper mill, Jordans are used to refine the waterborne pulp. A Jordan consists of a conical shell and rotating conical plug, both with steel blades on their mating surfaces. The refining action can be adjusted by decreasing the spacing of the revolving cone to the stationary cone within the limits of power available from the drive motor. In this case, drive motor power is 500 hp.

The action of the Jordan refiner results in high sound levels. With maximum refining power, the sound level was found to be 97 dBA at the aisle (102 dBA 1 ft from Jordan surface) during start-up with only one Jordan in operation. As normal operation required 6 of the 8 Jordans in operation with varied power settings, depending on degree of refining required, the operating sound level in the aisle was often at about 100 dBA. Although the paper maker did not have to be in the area continuously during the shift, he was required to make periodic adjustments, which took more time than the maximum exposure of 2 hr at 100 dBA permitted by current regulations. Some noise reduction was therefore required.

Problem Analysis

It was determined from vibration measurements that the major vibration surfaces were the conical shell, end cover plate, and outlet box. Shell acceleration measurements were made with a hand-held pickup attachment to the sound level meter to determine the major vibration surfaces as summarized below:

<u>Areas selected for treatment</u>	<u>Vibration (g)</u>
Shell surface, large end	15.9
Shell surface, rib	20
Flange face	10
Shell surface, center	15.9
Shell surface, rib	11.2
Shell surface, small end	5
Outlet box	7.9

<u>Areas not to be treated</u>	<u>Vibration (g)</u>
Bearing support	2.5
Overhead piping	1
Drive motor and bell (1)	0.9
Drive motor and bell (2)	1.4

Only sound level readings were obtained because octave-band data would not have added any information for these purposes.

Control Approaches Considered

Two possible solutions were considered: (1) complete enclosure and (2) partial lagging of the Jordan shell. Total enclosure of each Jordan was possible but was not considered as practical as lagging. There were 8 Jordans near each other; adjustment and maintenance would create problems, and sound absorption material inside the enclosures would not be compatible with the wet conditions of this paper mill. Partial lagging was chosen since it could be installed on the major vibrating surfaces producing the noise. Separation of lagging could be designed to allow for maintenance dismantling of the front face and plug. The sound-absorbing material of the lagging could be covered with layers of sheet lead, taped to form a water-resistant surface that would withstand cleaning normal to paper mills.

The lagging consisted of a resilient (and absorbing) layer of 3-in. Fiberglas grade TIW, covered by an impervious and heavy layer of lead sheeting to serve as the mass element and to contain the noise. In theory, a 1-lb/ft² lead sheeting, perfectly covering the area, would give an attenuation of 24 dB at 500 Hz and 28 dB at 1000 Hz. From a practical standpoint of making a more impervious continuous barrier for both noise and water from cleaning hoses, two layers of lead were used, each layer taped for tightest joints.

Alternate materials could be considered: The absorbing layer could be polyurethane foam, and the barrier layers could be lead-loaded vinyl. However, the Fiberglas is much more resilient, and thus preferred.

In another paper mill, a third method was chosen: enclosure for the operators. As the time actually spent in making the adjustments during the shift was small, the daily noise exposure index would be at or below the allowable 1.0 if 1-1/2 to 2 hr exposures at 100 dBA were balanced with the remainder of the shift in a protected area below sound levels of 90 dBA.

Since this reduction would require only a minimum shelter for 15-dBA attenuation, a simple construction could be used consisting of 1/2-in. plywood, on both sides of a 2- x 4-in. framing, with one door and a viewing window plus lighting. Because of paper mill conditions, the enclosure was heated and air conditioned for worker comfort. Recordkeeping could be done inside the enclosure.

The sound level was 77 dBA inside the control room and 97 dBA outside. Lowering the sound level inside the enclosure would require wall construction with a higher transmission loss material (such as concrete block).

Control Description

A sketch was made following the lagging design parameters discussed above, requiring 3-in. Fiberglas grade TIW, plus two top layers of 1/64-in. lead sheeting, all held to the surface by "stik-klips" glued to the surface (normal method of acoustic application in buildings). Each layer of the lead was waterproof-taped to protect the absorbing layer from water. Two layers were used to get best waterproofing.

Shafts, bearing boxes, and the drive motor were not lagged because vibration readings did not justify the noise control treatment as noted above.

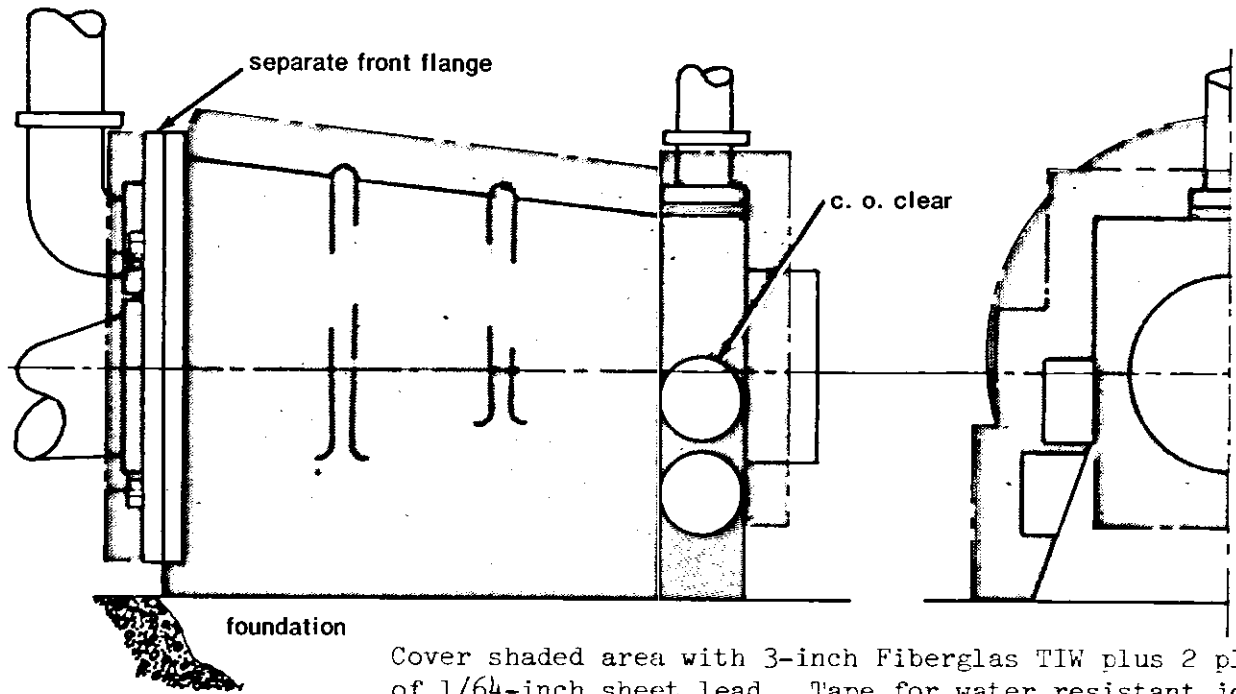
The sketch shown in Figure 6.36.1 was used by an acoustic contractor for estimating and installation purposes. Cost was \$600 per Jordan, averaged over all 6. Total enclosure cost would have been at least \$4,000 for each Jordan, based on a quotation from an enclosure supplier; thus, lagging achieved a net savings of \$3,400 per machine.

Results

For a single Jordan paper-pulp refiner, the sound level at the operator station was reduced by 11 dB, from 97 dBA to 86 dBA. With all 8 Jordan refiners similarly lagged and running at normal production, the aisle sound level ranged from 88 to 91 dBA. Even for unusually high production in the fastest mode, these same sound levels ranged from 92 to 94 dBA. This lagging produced acceptable daily noise exposures of less than unity.

Comments

Paper mill conditions should be studied carefully because the sound-absorbing material performance can suffer because of wet conditions in a paper mill. Maintenance methods were reviewed before design, leading to a separation of the lagging at the front flange so that it could be removed for maintenance.



Cover shaded area with 3-inch Fiberglas TIW plus 2 plies of 1/64-inch sheet lead. Tape for water resistant joint. Fasten stik-klips and caps.

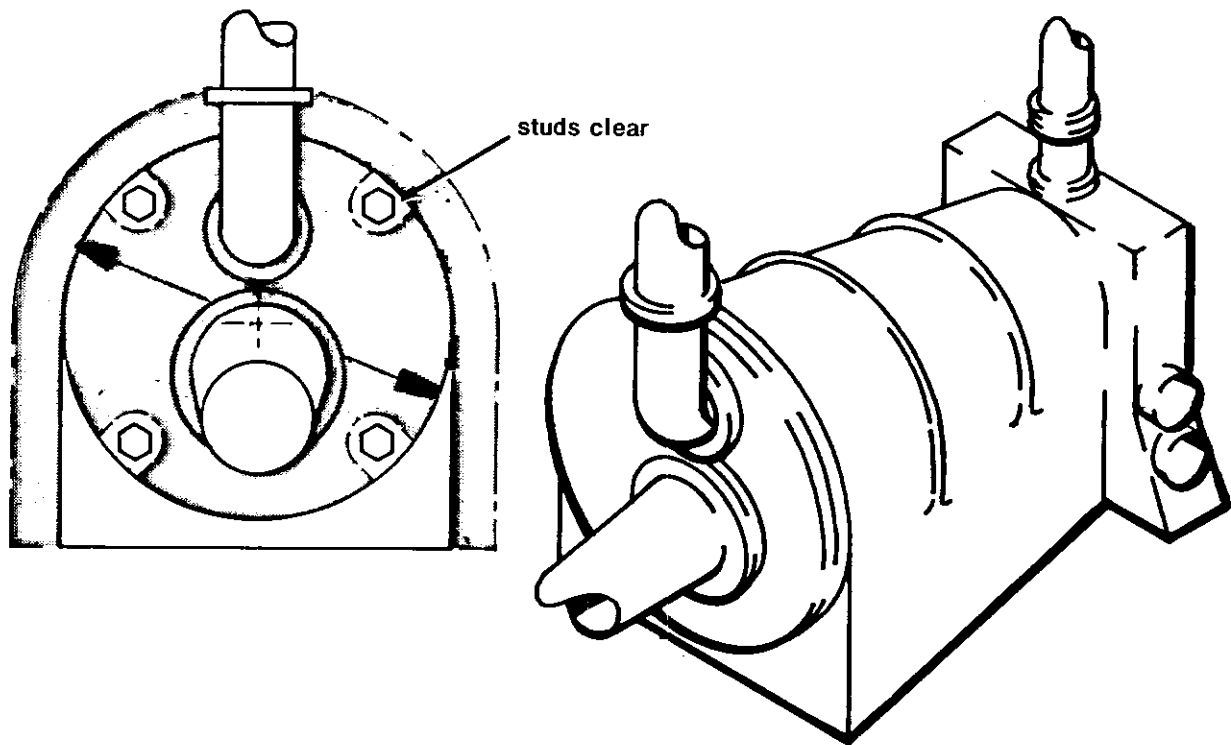


Figure 6.36.1. Noise reduction lagging for Jordan shell.

CASE HISTORY 37: PNEUMATIC SCRAP HANDLING DUCTS
(OSHA Noise Problem; Speech Interference Problem)

Problem Description

In a corrugated box factory, slit side-trim is removed from the conveyor by air. Trim blower fans with extra heavy blades cut the trim while conveying it via ducts to bins and balers. The 12-in. ducts are suspended from the ceiling about 10 ft from the floor, crossing a 40-ft-long work room en route to the bins and baler room. The trim is carried along in the ducts by the air, which normally moves about 6000 ft/min. The trim often strikes the duct walls (mainly at bends), causing noise.

In the case described here, ear-level sound level was 93 dBA. Noise reduction was desired to improve worker communication for operations under ducts and to meet the requirements for OSHA compliance.

Problem Analysis

Octave-band data were collected because this case required not only a reduction of a few decibels to comply with minimum regulations, but noise reduction for safety reasons, to control speech interference. Octave-band data provide a truer measure of speech interference than a single-number dBA reading. For the minimum compliance data, the dBA reading would have been adequate.

Control Description

The solution chosen was to wrap the problem duct locations with 2 in. of mineral wool building insulation to furnish a resilient and absorbing layer. Over this insulation were placed two impervious layers of heavy tar paper, spirally wrapped with 50% overlap.

Result

Noise was reduced considerably in the problem area: The sound level changed from 93 dBA to 72 dBA, a reduction of 21 dB. To the ear, the noise could hardly be heard above other noise. The octave-band comparison is shown in Figure 6.37.1. Although the standard materials used were very economical, special acoustic absorber pipe coverings with lead-filled vinyl sheeting could also have been used and may have given even more attenuation. This was not needed here.

There are no detailed costs for this case history. However, since the materials are inexpensive, the major cost must have been labor. The job was probably done for less than \$200.

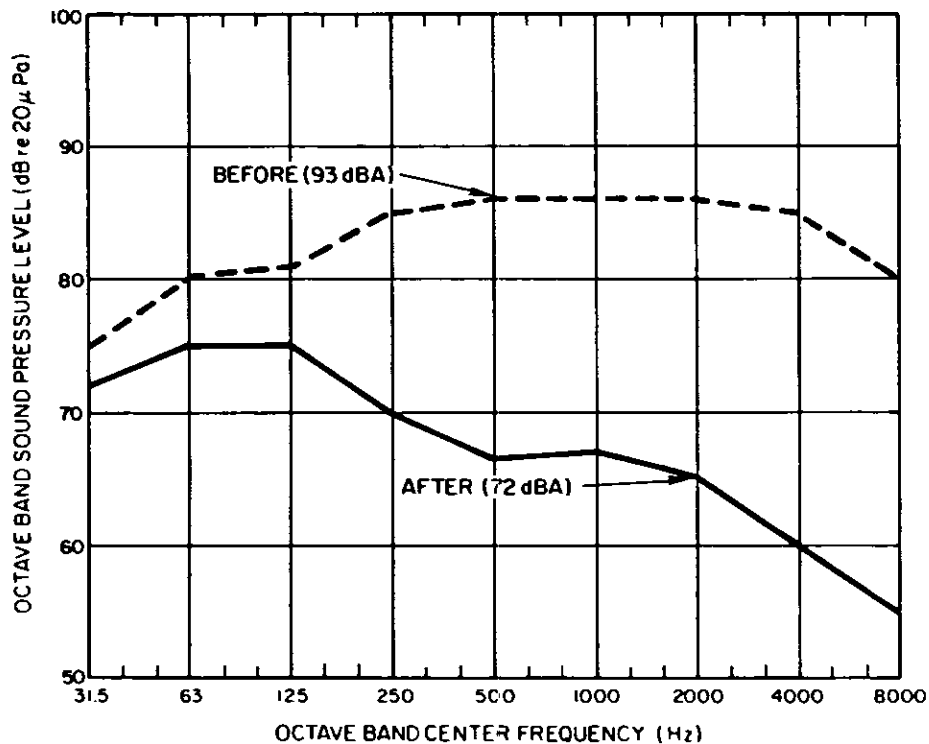


Figure 6.37.1. Noise levels in scrap duct for corrugated box industry, before and after covering.

If less attenuation had been required for OSHA compliance only, the sheet metal ducts could have been damped and transmission loss improved by gluing 1/32-in. sheet lead to the duct outer surface. Comparison with the experience at other installations indicated that a 5-dB attenuation would probably have been attained. (See Case History 5 for other methods.)

Comments

Use the most economical methods to attain the attenuation required. The building insulation plus roofing paper used here is a very economical solution.

Note that a large overlap was used; lack of overlap on any wrapping will cause leaks and reduce attenuation.

CASE HISTORY 38: BLOOD PLASMA CENTRIFUGE
(OSHA Noise Problem)

Problem Description

This plasma production room has two parallel banks of centrifuges, 15 to a bank, plus refrigeration units. A sketch of one centrifuge is shown in Figure 6.38.1. Centrifuge spinning frequency is 13,000 rpm (217 Hz). Though centrifuges appeared to be the major noise source, refrigeration units were also evaluated. The same refrigeration units without centrifuges are used in a separate reconstituting room.

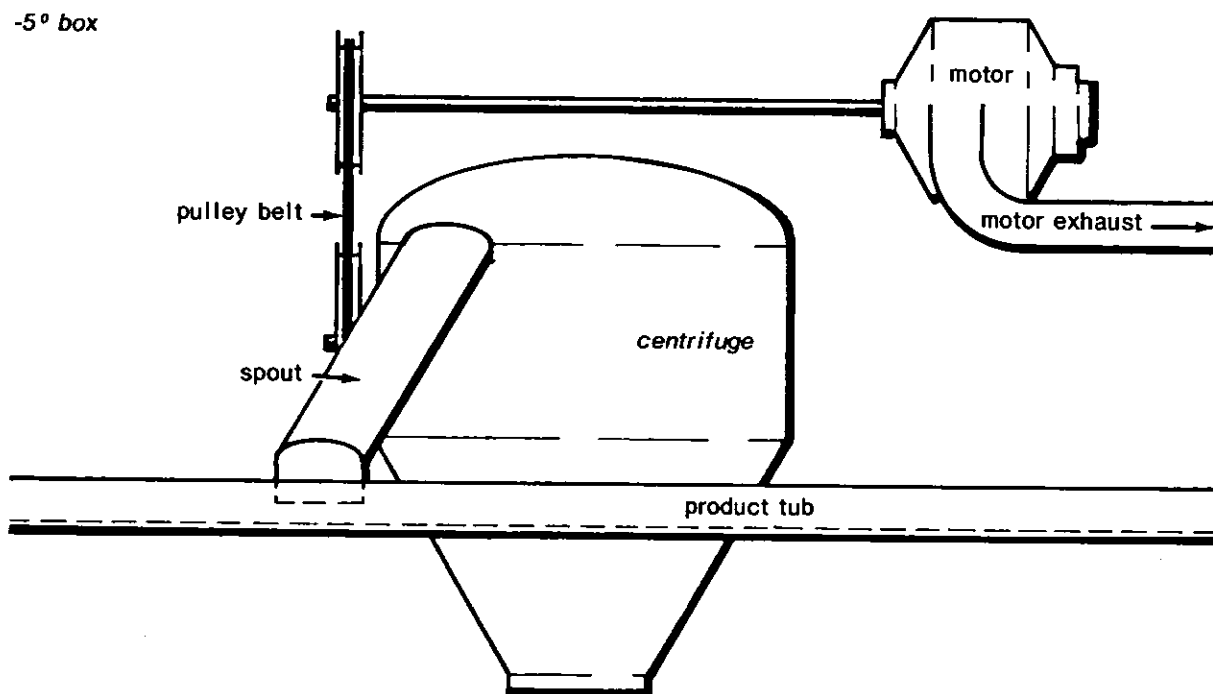


Figure 6.38.1. Sketch of one centrifuge (front view).

Problem Analysis

Operator sound level was 97 dBA with one bank in operation; 100 dBA was predicted with both banks operating. Figure 6.38.2 shows the measured sound pressure levels at the operator positions in both the centrifuge and refrigeration rooms and also a 90-dBA criterion spectrum.

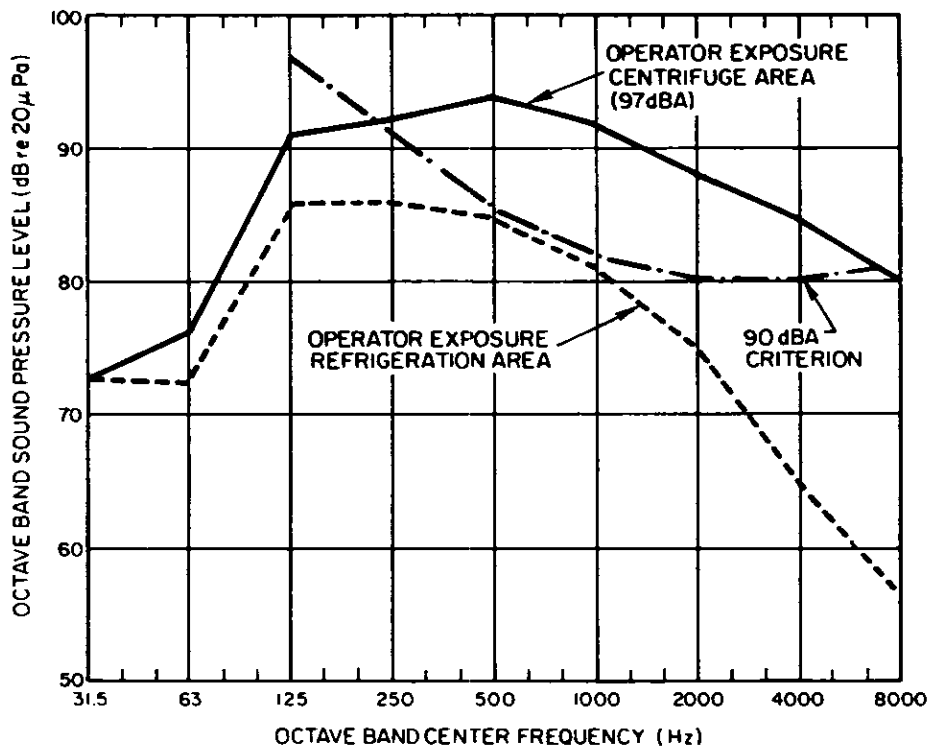


Figure 6.38.2. Sound pressure levels at operator position.

Close-in diagnostic readings were made around the centrifuges at the locations shown in Figure 6.38.3.

A comparison between the operator position spectrum in the centrifuge room and the 90-dBA criterion curve indicates that the 500- to 4000-Hz bands merit the most attention. The fact that the operator position spectrum in the refrigeration room is considerably lower in level in all octave bands suggests that the refrigeration unit noise is not a significant contributor to the noise exposure in the centrifuge room.

Close-in data show that the maximum sound pressure levels in the 500- to 4000-Hz octave bands occur close to the motor exhaust and near the pulley guard surface. The pulley guard surface was presumed not to be an important noise source; it was reasoned that the sound pressure levels measured near the pulley resulted from motor exhaust and other sounds being reflected from the highly reflective pulley guard surfaces.

Results of the measurements indicated an unacceptable exposure when the operator was exposed for 4 hr to both centrifuge banks (predicted level at 100 dBA). Under these conditions, the operator's daily dose was 2.0, which thus exceeded the acceptable exposure of 1.0, as specified by OSHA noise regulations.

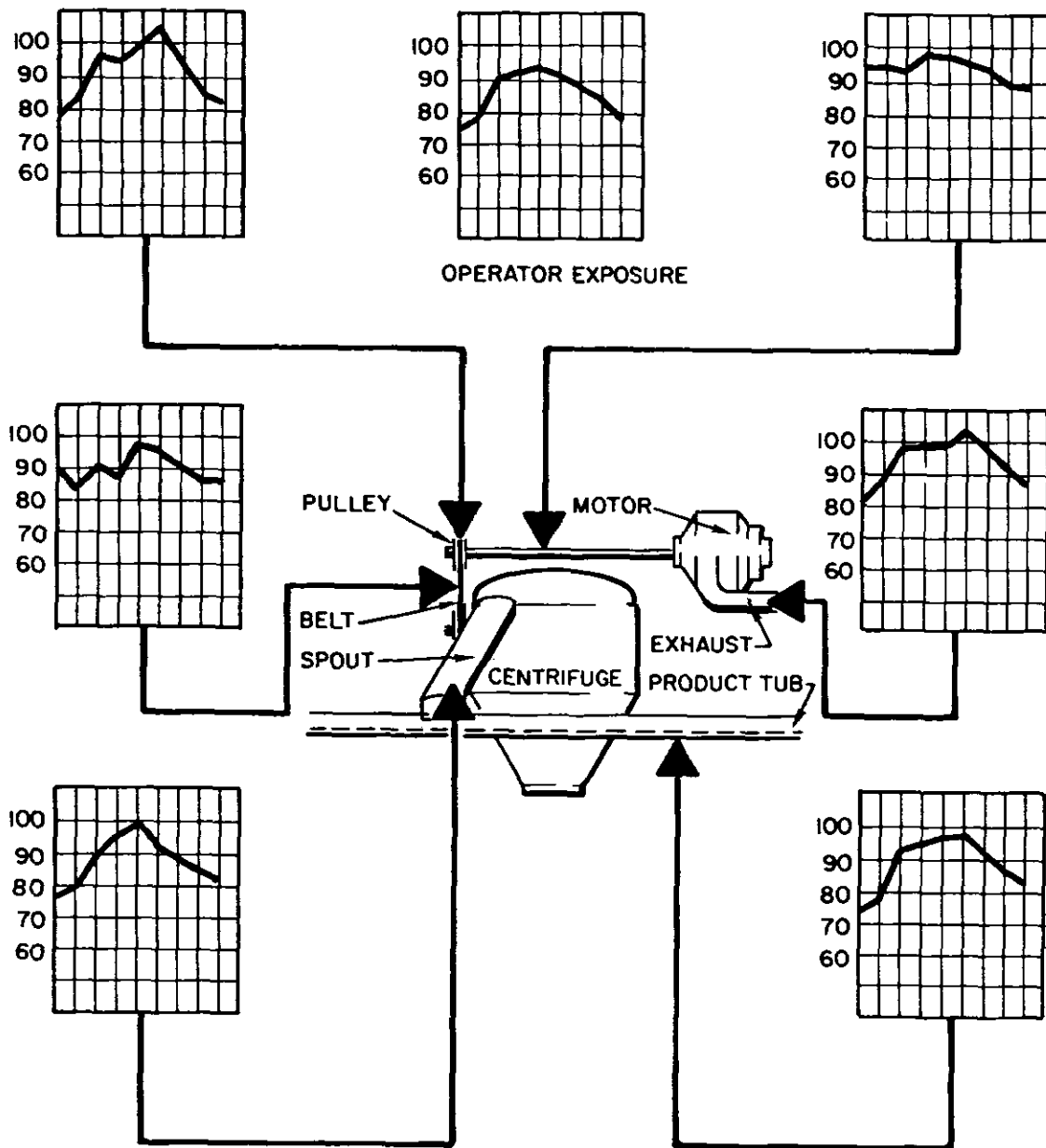


Figure 6.38.3. Sketch of centrifuge showing locations for close-in diagnostic readings.

Control Approaches Considered

There are three general locations for controlling noise: at the source, along the transmission path, or at the receiver. Two could be used in this case. A properly designed and constructed muffler or partial enclosure for the centrifuge motor exhaust would provide the necessary source control, using materials and geometric configuration that have effective attenuation in the octave bands of interest. Such a control measure would provide an expected 3- to 7-dB attenuation.

Noise control measures can also be used along the path of transmission. The paths of airborne noise transmission were from direct and reverberant fields such as walls, floor, and ceiling, which supply very little sound absorption.

For direct field reduction, barriers with the proper transmission loss, dimensions, and orientation may be used. The reverberant field can be controlled by the addition of absorbent materials. These combined measures would reduce operator exposure 5 to 15 dB.

Control Description

In this case, after discussion, two of the possible control methods were eliminated. The hard and impervious walls had to remain because of the need for daily sterilization by high-pressure steam and water hosing and hand scrubbing. A porous absorbent surface would provide areas for bacterial growth and would not withstand the rigorous daily cleaning. A barrier to shield the operator from the centrifuge motor noise was eliminated from consideration because it would block the proper flow of refrigerated air. Even a small warming of the plasma would produce an unusable product. It was decided to try the motor exhaust muffler and see how much noise reduction could be achieved.

The muffler was designed with a stainless steel outer skin, lined with acoustical absorbent spaced 2 in. from the inside of the steel shell, with small blocks. The 2-in. air space allows absorption since it reflects from the inner steel surface and back through the absorbent. The muffler has one 90° bend, as shown in the sketch in Figure 6.38.4. In-house shop cost was estimated at \$300.

Results

Noise at the operator's position was reduced from 97 dBA to 92 dBA, satisfactory for a 4-hr exposure. The motors of both centrifuges must be treated if they operate together.

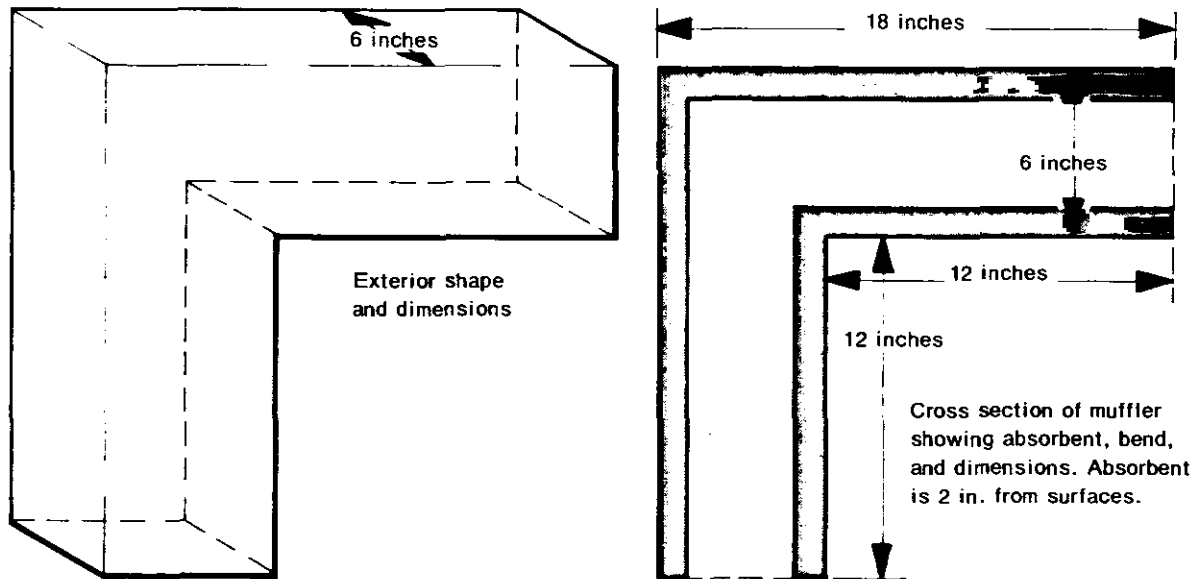


Figure 6.38.4. Motor exhaust muffler.

Comments

An airtight seal at the junction of muffler and motor is very important; resilient caulking compound was used as a sealant. An air leak with an area of no more than 10% of the muffler cross section would produce as much noise as if the muffler were not there at all. An intake muffler would probably also help, but noise from other sources would then become prominent.

Effectiveness of noise control is reduced if the path of vibration transmission is not held to minimum. Accordingly, it was very important to use as few absorbent spacers as possible. In so doing, the steel skin vibration was kept small. The spacers can be made of damping material to reduce resonant vibration of the skin.

Although one main control solution would satisfy the noise control requirements, alternatives should be discussed with company representatives, as they are able to specify important operating, maintenance, and production constraints that may limit the ideal noise control treatment.

CASE HISTORY 39: PNEUMATIC MOTORS
(OSHA Noise Problem)

Problem Description

Air-operated motor hoists are a noise source in many industries that make extensive use of materials-handling systems.

Control Description

As the noise source is the exhaust air, this exhaust can be muffled by using off-the-shelf mufflers selected for the air pressure and delivery of the exhaust.

Results

A typical octave-band analysis, before and after installation of an exhaust muffler, is shown in Figure 6.39.1. Note the rising spectrum that is characteristic of freely escaping high-pressure gas. Another case showed the following A-weighted sound levels at the floor for a 1-ton air hoist:

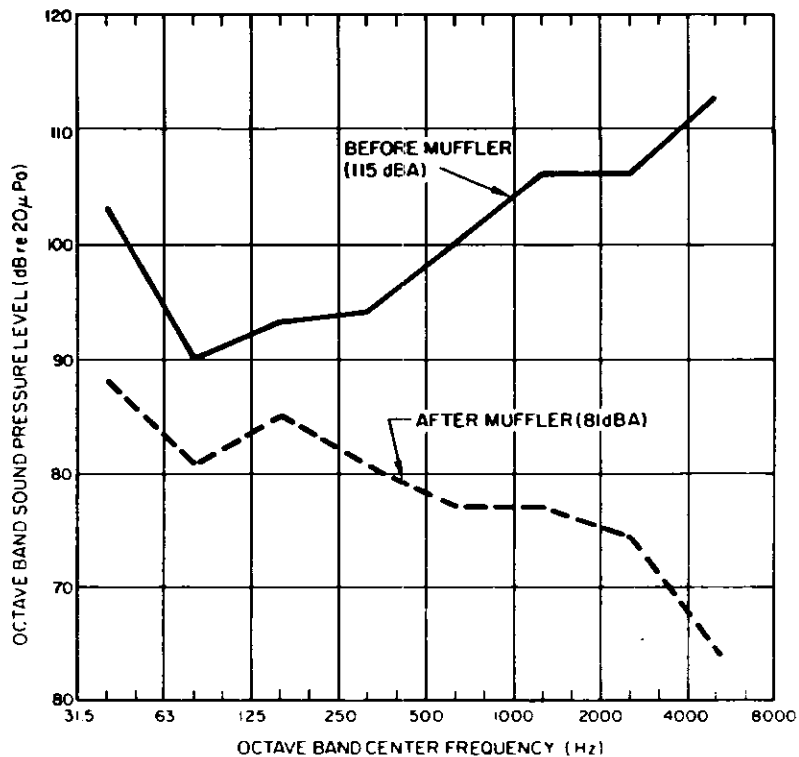


Figure 6.39.1. Effect of muffler on air exhaust from hoist.

	<u>No Muffler</u>	<u>With Muffler</u>
Up - no load	98	85
Up - 600 lb	96	84
Down - no load	102	88
Down - 600 lb	100	86

Air exhaust from other tools can be similarly muffled. Newer designs include mufflers, which should be specified at purchase.

CASE HISTORY 40: DEWATERING VACUUM PUMP*
(OSHA Noise Problem)

Problem Description

In paper manufacturing, a fine-grained mineral slurry is dewatered by a suction press and a vacuum pump. The mixture of air and water discharges into a drain; slugs of water make the discharge pulsate irregularly. Although no workers stay long in the discharge area, the levels are high even at considerable distances from the discharge pipe. In one instance, the pipe was inadvertently tuned to the pump pulse frequency, thus compounding the problem.

Control Description

The solution is a special combination muffler and water/air separator called a snubber. Besides use of the snubber, the line length should be changed to detune the system.

Results

Figure 6.40.1 shows the effect of adding a snubber and the greater effect of two snubbers. The low-frequency resonances are greatly reduced by this direct scheme. Sound-levels close to the discharge pipe were changed from 112 dBA to 103 dBA with one snubber and 93 dBA with two snubbers. Some of the low-frequency reduction is probably due to the detuning effect of the change in the acoustic length that the snubbers introduce.

*Young, R.L. 1958. Practical examples of industrial noise control, Noise Control 4 (2): 11.

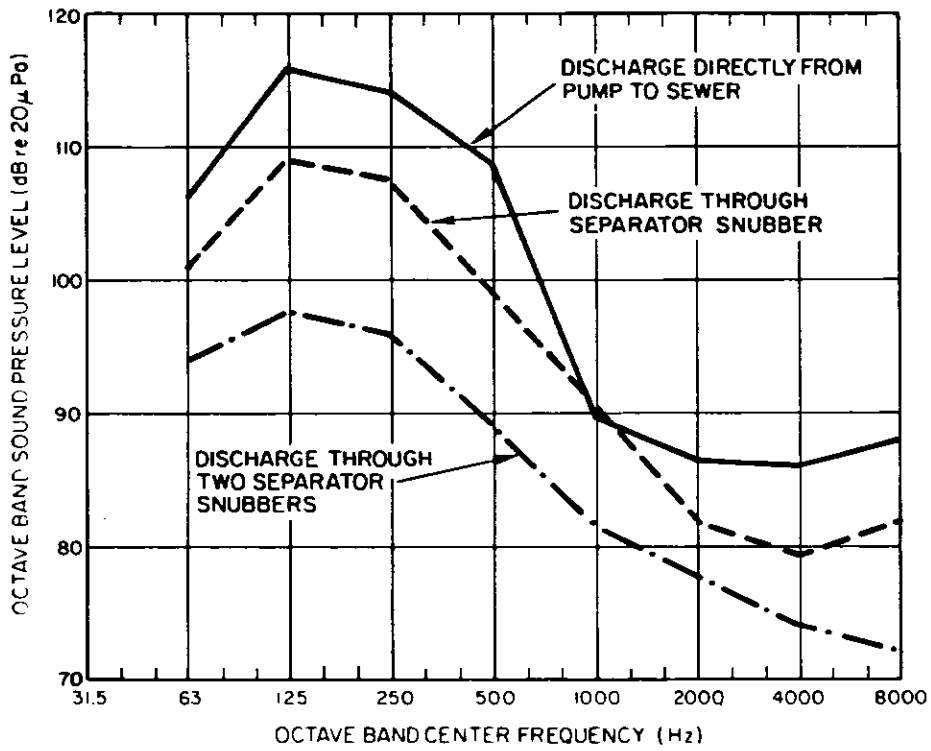


Figure 6.40.1. Octave-band analysis of paper mill vacuum pump noise (converted from old octave-band designation).