CASE HISTORY 25: PUNCH PRESS (OSHA Noise Problem)

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Talon, Division of Textron
626 Arch Street
Meadville, Pennsylvania 16335
(814) 337-1281

Problem Description

This case history concerns high-speed (approximately 1200 strokes/min) Bruderer punch presses which are centrally located in a 20-m by 30-m steel building. Operation of the 40- and 70- ton presses causes OSHA noise overexposures of the three workers in the general area around the press, as well as of the two press operators.

Problem Analysis

The presses were clearly identified as the cause of the noise problem because sound levels were low when the presses were not operating and between 95 dBA and 100 dBA, depending on proximity to the units, when they were in operation. Action was initiated because management became aware that the press room was extremely noisy in comparison to other plant operations.

Octave-band readings showed most of the sound energy from the presses was in the higher frequency bands, indicating a simple enclosure around the presses could be effective. Because the press operation is automated, a 4-sided enclosure with penetrations for stock feed and parts discharge was deemed acceptable, and plans for the treatment were made up.

Control Description

The press enclosure design called for formed steel angles to be used as structural members to support removable enclosure panels – the concept is shown in Figure 6.25.1. The ultimate panel system employed (see comments below) consisted of 1/2-in. plywood framed on one side with 1 × 3's tacked on. Expanded sheet metal formed a backing on the framed side of the 2-ft-wide panels. Foamed-in-place foam was then applied to the backing. The panels were hung by clips to cross members on the framing. Each panel was thus easily removable for press screening.

Results

Sound levels at the closest worker position to either press – the operator who sits 2 ft away from the die – are now in the 88- to 90-dBA range. Treatment interference with the operation is nil, and productivity is unaffected. Total cost for the two press enclosures was in the $1000 to $1500 range.

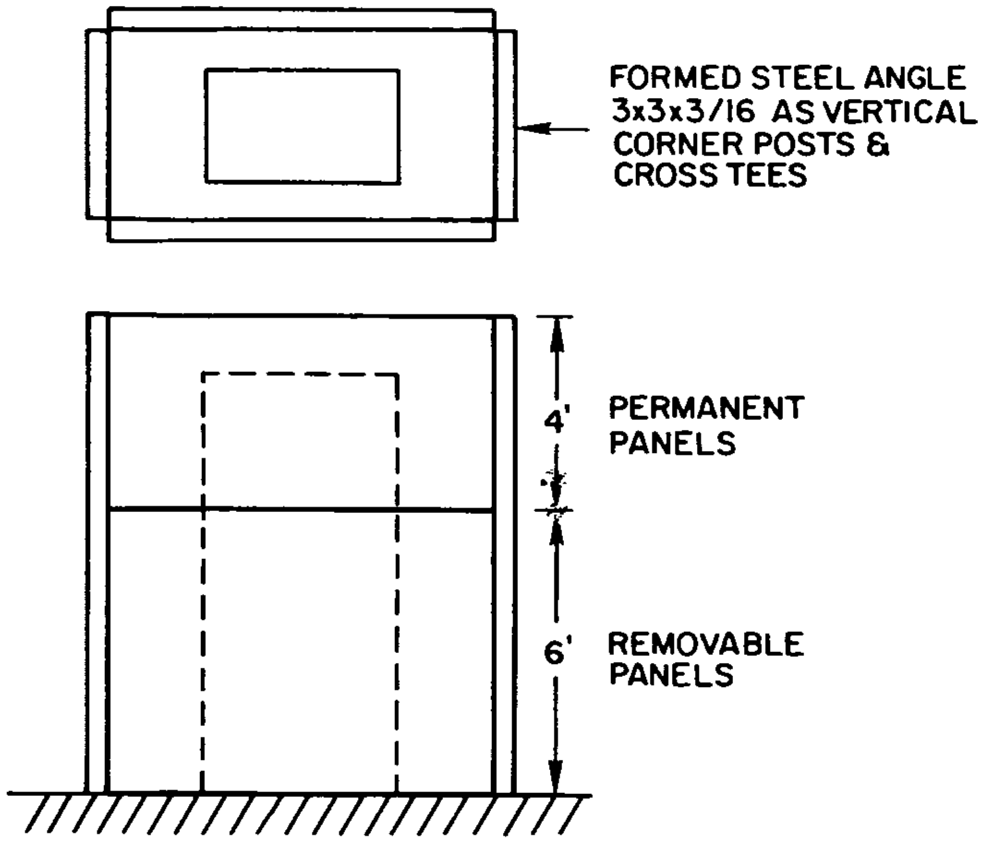

Figure 6.25.1. Press framing and location of panels.

Comments

Initial panel designs were found unacceptable: Panels of 16-gauge galvanized steel backed with 1-in.-thick glass fiber duct insulation were found to rattle, and the glass fiber became pulverized by vibration and became unglued.

The implemented treatment is clearly acceptable. It reduces noise exposure to compliance levels for minimum cost and impact on operation. However, better performance could have been obtained (at added expense) by using standard acoustical panels or larger plywood sections to minimize acoustical leaks at the many joints. The open top could also be sealed.

The expanded foam adds little to treatment performance, since its acoustical properties are nil. Acoustical foam, held in place with expanded metal, would probably improve the enclosure performance.

CASE HISTORY 26: PUNCH PRESS (OSHA Noise Problem)

Keith Walker
U.S. Gypsum Company
P.O. Box 460
Round Lake, Illinois 60073

Problem Description

This case history concerns noise emissions caused by operation of a high-speed 290-ton stamping press. Sound levels in the vicinity of the press were high enough to contribute to OSHA noise over-exposures of workers near the press as well as of the press operator.

Problem Analysis

Sound levels were found to be in the 95-dBA to 101-dBA continuous slow meter response, at distances of 15 to 25 ft from the operating press when it was the only noise source operating.* The U.S. Gypsum Company decided to install their Acoustisorber (TM) Industrial Sound Control Panel System around the press, to determine how effective the system would be in reducing sound levels in the shielded positions. (Operator position noise exposures were studied separately and are not discussed in this case history.)

Control Description

The panel system employed consists of 2-ft × 8-ft modules made of hardboard on one face, expanded and flattened metal on the other side, with a mineral fiber absorbent sandwiched in between. The absorbent is fully wrapped with a thin heat-shrunk plastic film. Individual panels are joined together by light steel framing to form enclosure walls. The two long walls in this example were suspended on an overhead roller track for access to the press. The installation is open-topped and about 24 ft × 32 ft in size. Walls are 16 ft high, except at one short end where the height was dropped to 8 ft to allow for overhead crane clearance. Material feed and discharge are through openings cut into the short sides of the walls.

Material costs were approximately $1600.

Results

Sound levels at the original measurement locations were reduced by 7 to 14 dB to a maximum of 88 dBA at those locations. (See Figure 6.26.1.) Enclosure systems need not always be elaborate

*Distances chosen to represent possible nearby worker locations.

when moderate amounts of noise reduction are needed, and relatively inexpensive materials can be used. The panels provide more than enough transmission loss, mainly from the hardboard backing, to reduce sound levels by the amount needed. The key is making sure that spillover sound, escaping over the top of the enclosure, through joint leaks, etc., does not short-circuit the transmission loss potential. The absorbent material on the inner surface of the walls minimizes that effect here.

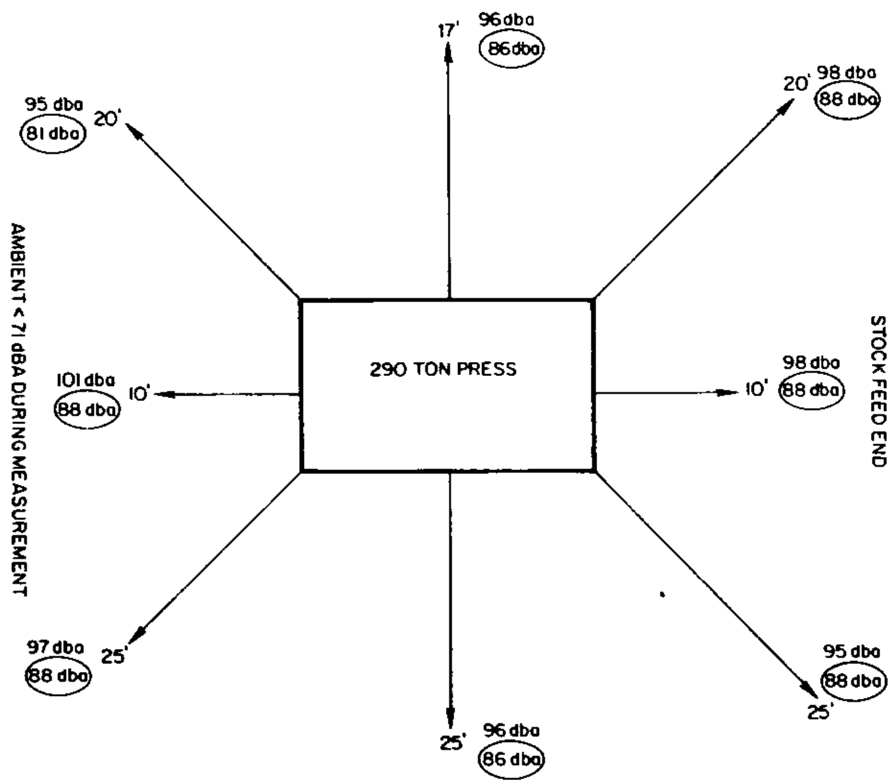

Figure 6.26.1. Sound levels at the original measurement locations, which were reduced to a maximum of 88 dBA.

CASE HISTORY 27: BRAIDING MACHINE (OSHA Noise Problem)

I.D.E. Processes Corporation
Noise Control Division
106 81st Avenue
Kew Gardens, New York 11415
(212) 544-1177

Problem Description

Braiding machines are used in the textile industry to combine several filaments of material into a single braided strand. The braiding process is accomplished mechanically by having many individual material "carriers" move simultaneously around the periphery of a table in such a fashion that the carriers criss-cross each other as they move. The material strands, fed from the carriers, are thus formed into a braid. The whole process is similar to the interweaving of ribbons on a Maypole. In this situation, however, considerable noise is generated by the gearing and the impacts associated with the carriers as they constantly change direction. Typically, many braiding machines are assembled in multiple rows and operate simultaneously, tended by operators who make sure the machines are functioning properly.

For the project involved in this case history, I.D.E. Processes Corporation, Noise Control Division, was called in to help a manufacturer of medical sutures bring worker noise exposures of his braider operators down to an equivalent of 85 dBA or less when a bank of machines was operated. Because of funding limitations, I.D.E. was asked to work on a prototype installation that would be evaluated after normal working hours, when the treated equipment could be run independently of other untreated machines in the area.

Problem Analysis

In this problem, the client specifically asked for an enclosure control to be installed after other equipment modifications had been tried and rejected, including replacing metal components with their nylon equivalents. Sound levels were measured at aisle positions, 2/3 m in front of the untreated equipment, first, with just the bank of machines to be enclosed running and, second, with all equipment turned off. The sound level was 101 dBA (with peak frequencies 2000 to 4000 Hz) with the bank of 26 braiders running and 57 dBA maximum with the machines turned off, indicating that the problem noise originated at the braiding machines.

The enclosure design had to provide a minimum of 16 dB of noise reduction on a dBA scale, to achieve 85 dBA guaranteed. In addition to the acoustical requirements, the client specified that the control would have to be robust and sanitary (a medical product was involved) and could not cause any significant worker inconvenience.

Control Description

The custom-designed I.D.E. enclosure constructed for this problem is shown in Figures 6.27.1 and 6.27.2. From the photographs, it is easy to see that the operators retain good visibility of their machines. Several aspects are not revealed by the pictures: The windows slide on roller bearing, making worker accessibility relatively easy and fast. Panels on the bottom of the enclosure also slide. All windows and the bottom panels are removable for maintenance. Gravity ventilation sufficient for these machines is furnished via the silenced vent openings visible below the bottom panels. The outer skin of the enclosure panels is made of corrosion-resistant steel. The inner skin of the panels is of perforated sheet metal that covers an acoustical fill material, thereby making the inner surface acoustically absorbent and thereby minimizing any build-up of sound inside the enclosure. A layer of woven glass fiber fabric protects the inner fill from working out of the perforated sheet metal.

Result

Sound levels at the aisle positions have been reduced by 18 dB to 83 dBA when only the treated bank of machines is running. It should be noted that the achieved noise reduction is not a characteristic reduction of I.D.E. acoustic panels but rather an overall reduction of the entire system, consisting of approximately 50% glazed area of the total enclosure surface. The gravity ventilation is acoustically treated and compatible with the enclosure attenuation.

Operators are exposed to higher sound levels only for short periods of time, when opening one of the windows to work on a particular machine. Under these circumstances, the machine being worked on is typically shut off, and the worker is exposed to noise coming from more distant machines. Measurements taken at the enclosure at a position occupied by an operator tending a machine, while the other 25 machines are running, confirmed that such an exposure would contribute only a small fraction to his overall noise exposure — the sound level was 92 dBA under these conditions.

Since the enclosure, when installed in an existing plant, reduces aisle clearance between adjacent rows of equipment, some braiding equipment users may find it necessary to move their equipment in order to accommodate the 10- to 20-cm loss of clearance caused by the treatment. New plant layouts, of course, can accommodate required walkway clearances.

Figure 6.27.1. Braider enclosure.

Figure 6.27.2. Braider enclosure, another view.

CASE HISTORY 28: REFRIGERATION TRUCKS (Community Noise Problem)

Richard C. Potter
Bolt Beranek and Newman Inc.
50 Moulton Street
Cambridge, Massachusetts 02138
(617) 491-1850

Problem Description

After loading at a frozen food department, 12 refrigeration trucks were left at the loading dock overnight for early morning deliveries. A neighbor complained to state officials about the noise of the refrigeration unit compressor motors running intermittently. The refrigeration trucks were visible from the complainant's property. As a result, notice was served to the owner to reduce the sound levels at the boundary of the property to less than 44 dBA.

Problem Analysis

Bolt Beranek and Newman Inc. was called in to study the problem. Two techniques to reduce the radiated sound level were developed and offered to the client for his consideration. The first involved lining the loading dock roof with acoustic absorbent panels and driving the trucks out of the dock, turning them, and driving them head first into the dock for the overnight stay. The bodies of the trucks would then shield the refrigeration units from direct radiation, and the close-fitting absorptive material would absorb the reflective sound passing over the trucks. Another condition was that the dock would be kept full of trucks to restrict reflective sound around the side of the trucks.

An alternative solution was to enclose the loading dock fully with acoustic roll-up doors and to fit an air circulation system to remove the heat generated by the refrigeration units in hot weather.

Control Description

While the truck-turning and acoustic treatment of the roof were considered to be sufficient to provide the required reduction in radiated sound, the fact that little visible effort had been taken would probably influence the attitude of the neighbors. Hence, the second approach was selected, even though it was more expensive, because the visual aspect of the problem was considered important. With the roll-up doors, the trucks would be out of sight of the neighbors, and their sound could not be heard. The action taken by the company in response to the community's complaints would be readily apparent.

The doors chosen were thermal insulation doors with a positive seal to provide the necessary acoustic transmission loss and proper acoustic seal. Two quiet 500-cfm units were roof-mounted to provide exhaust and make-up air, respectively.

Results

The installation was approved, built, examined by state authorities, and pronounced acceptable.

Comments

In community noise problems, and especially when the problem is annoyance from low-level sound sources, it is important that other-than-acoustic aspects be considered. Often, the fact that someone is aware of, and is constructively trying to solve, the annoying condition is more important than eliminating the problem. Consultation with all parties and the visibility of controls can be effective tools in dealing with annoyance problems, as in this case, where the sound level of the annoying source was much less than that caused by traffic, but was also apparent as a continuous noise from a stationary source.

CASE HISTORY 29: SPIRAL VIBRATORY ELEVATOR (Hearing Conservation Noise Problem)

Industrial Acoustics Co.
1160 Commerce Avenue
Bronx, New York 10462
(212) 931-8000

Problem Description

Spiral vibratory elevators are used as part of the handling equipment to cool hot processed ingredients while lifting them from one level to another 6 m higher at the Melton Mowbray factory of Pedigree Petfoods Ltd. The sound level in the immediate vicinity of the elevators is 104 dBA. Plant management aimed at reducing elevator noise to below that of the existing workshop ambient level of 84 dBA.

Problem Analysis

A reduction of the elevator noise of at least 30 dB was required in this situation. Because the operation is automated, consideration was given to enclosing the two units involved. Such a treatment would normally be considered routine. In this case, however, because a food processing facility is involved, there are rigid requirements to prevent contamination of the food products from acoustic infill particles used in the construction of the enclosure panels. In addition, the enclosure had to accommodate product heat loss.

Control Description

IAC designed an acoustic enclosure to surround both elevators, using their 100-mm-thick modular Noishield(TM) panels (see Figures 6.29.1 and 6.29.2). Acoustic tunnels were incorporated in the design at the feed conveyor inlets to the elevators. A forced ventilation system was also incorporated in the design to supply a flow of air sufficient for process and machinery cooling. Two IAC Power-FLOW(TM) silencer units were included at the intake and discharge points of the system to ensure that there would be no leakage of elevator noise through the ventilation system.

Access to the interior of the acoustic enclosure, mainly for machinery maintenance, was afforded by a double-leaf acoustic door having a clear opening of 2000 mm × 1530 mm. An acoustic observation window of double safety glass was provided on each side of the access door.

The sanitation problem was met by the inclusion of a polyethylene membrane between the acoustic infill and the perforated skin of the interior side of the panels.

Results

After the erection of the enclosure was completed, a noise survey determined that the planned minimum noise reduction had been comfortably achieved and that, at a distance of 10 ft from the acoustic structure, the elevator noise could not be distinguished above the general shop sound level, 84 dBA.

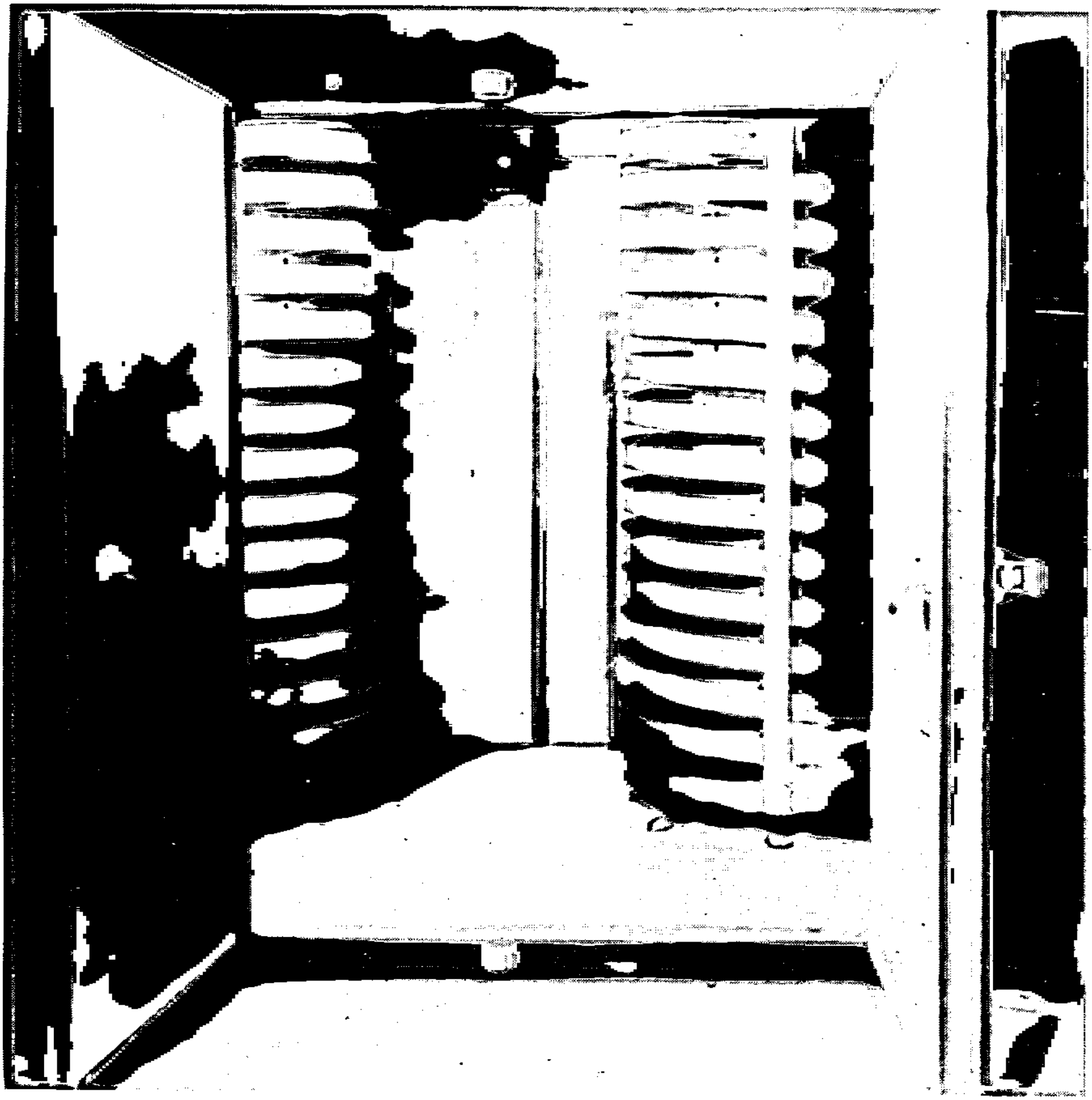

Figure 6.29.1. Detail of acoustic enclosure: doors.

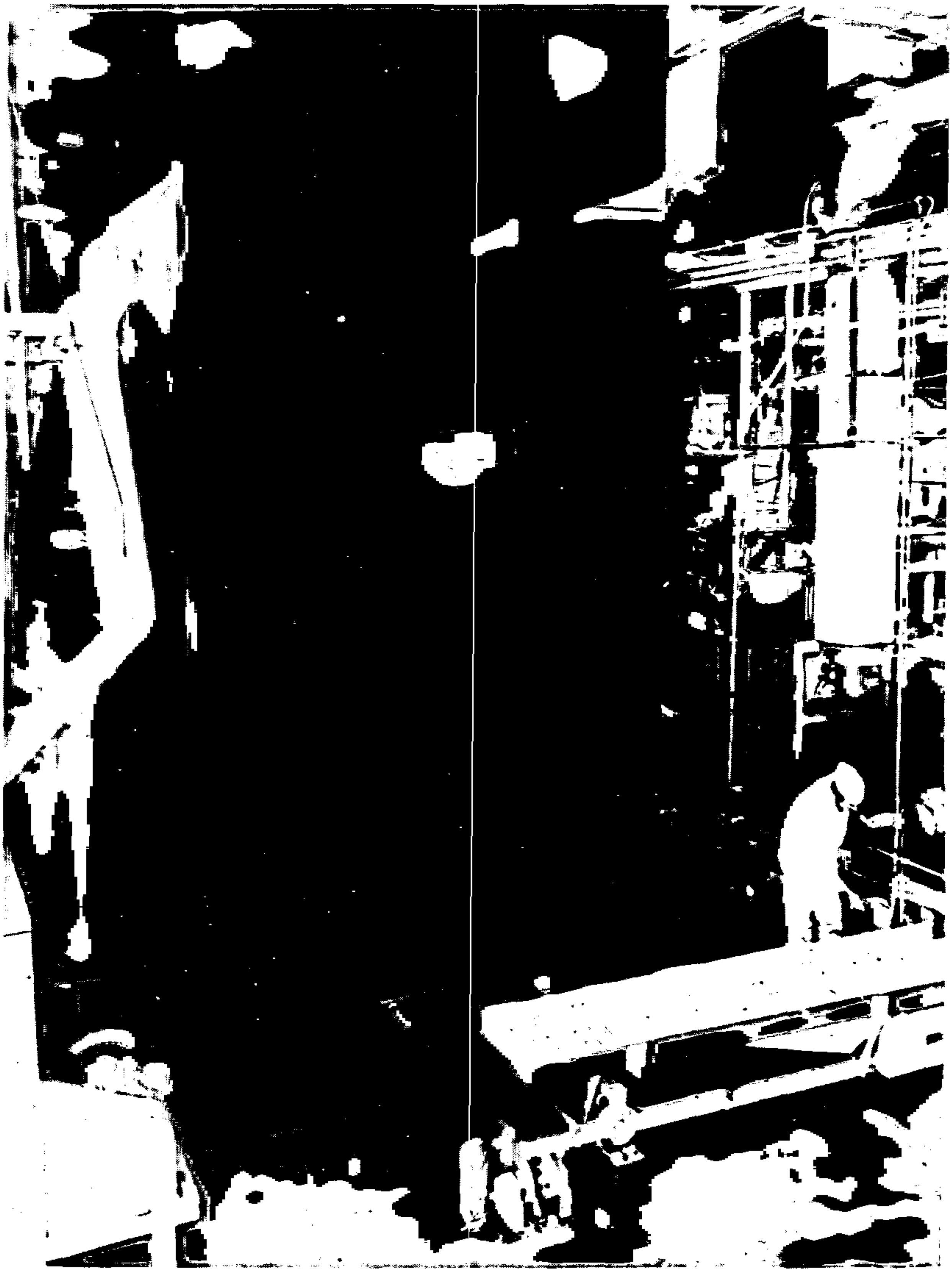

Figure 6.29.2. Acoustic enclosure around elevators.

CASE HISTORY 30: MOTOR GENERATOR SET

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Westinghouse Electric Corp.
Research and Development Center
1310 Beulah Road
Pittsburgh, Pennsylvania 15235

Problem Description

Operation of a motor generator set caused a 94-dBA sound level at a position 5 ft from the unit, giving rise to complaints from nearby workers.

Problem Analysis

No detailed control selection analysis was attempted here, as the solution is relatively straightforward. However, estimates of the expected benefit of the selected control – an enclosure – were made, based on calculations such as discussed previously in this *Manual*.

Control Design

The enclosure was built of 3/4-in. plywood lined on the inside with 1/2-in.-thick glass fiber, such as is used for lining ducts. Figures 6.30.1 and 6.30.2 show the motor generator set enclosure near and surrounding the noisy equipment and Figure 6.30.3 shows a cross section of the enclosure. Note the acoustical duct at the base of the enclosure, which allows for air supply.

Results

Figure 6.30.4 shows before, after, and predicted data. A 10-dB reduction in sound level was achieved here.

Figure 6.30.1. Photograph showing the installation of the high-frequency MG set enclosure.

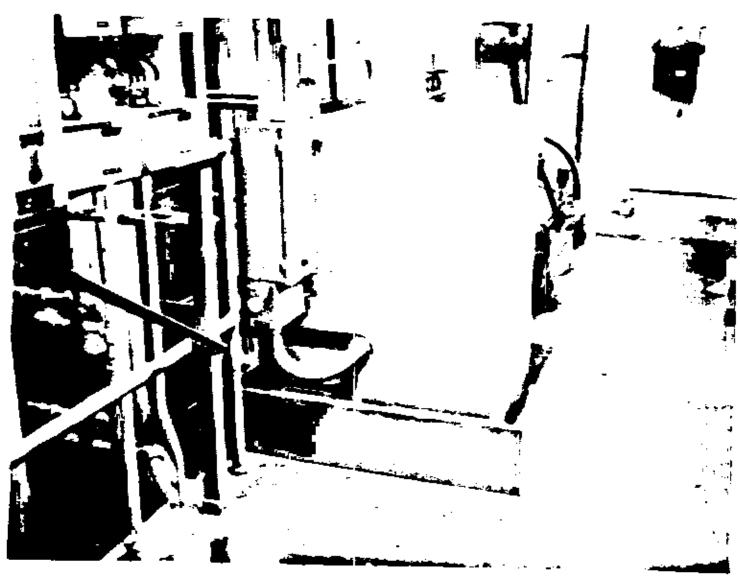

Figure 6.30.2. Photograph of the installed MG set enclosure.

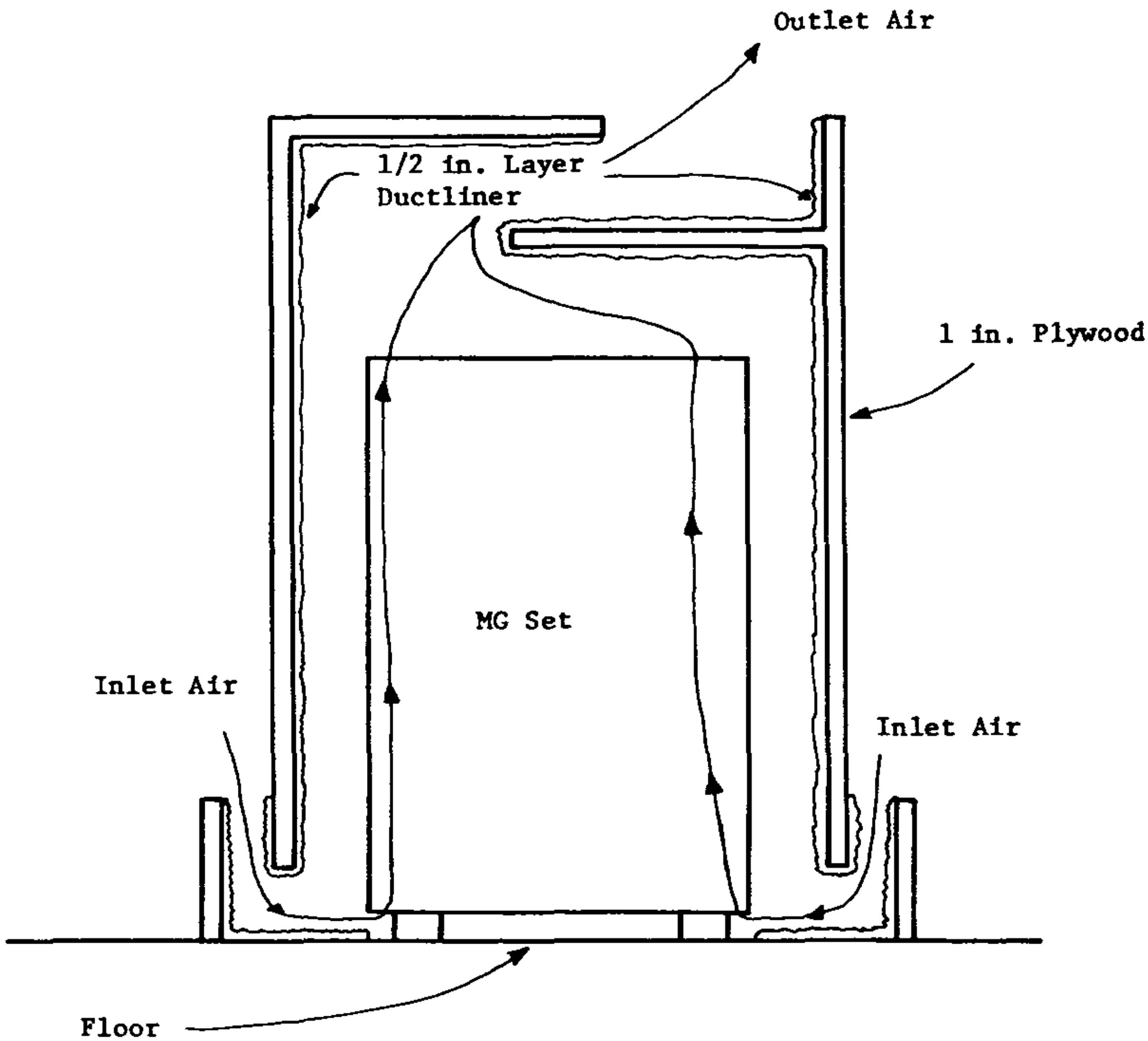

Figure 6.30.3. Cross-sectional sketch of the high-frequency MG set enclosure.

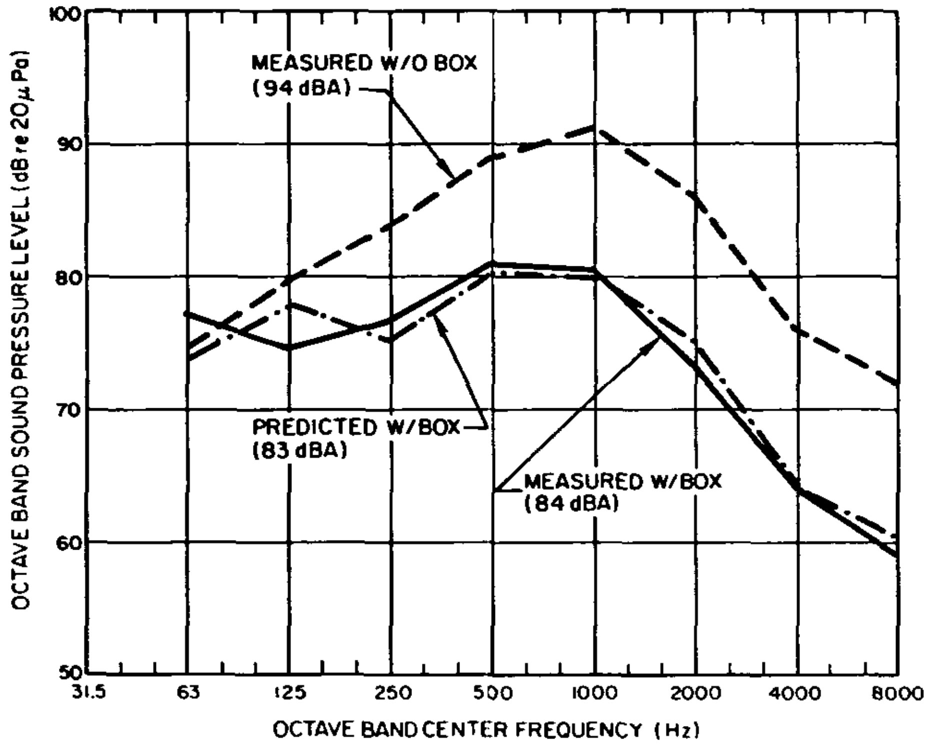

Figure 6.30.4. Before, after, and predicted data for motor generator set.

CASE HISTORY 31: FILLING MACHINES
(OSHA Noise Problem)

Dr. Walter W. Carey
The Nestlé Enterprises, Inc.
100 Bloomingdale Road
White Plains, New York 10605
(914) 682-6716

Problem Description

Two Nalbach filling machines used to fill freeze-dried coffee in glass jars were located in a 65 ft × 23 ft × 10 ft room at the Nestlé Company's Sunbury, Ohio plant.

There are two fixed worker stations for each machine. An operator station is directly in front of the filling machine, and an inspection station is located downstream of the machine discharge conveyor. A roving worker also works in this area. The filler operator maintains a steady flow of bottles into the filling machine and checks and adjusts the filled weight of spilled product as required. The inspector's function is to ensure that each jar is properly filled and that lids are securely fastened to the jars. The roving worker fills the lid bins with lids and maintains cleanliness in the area.

Problem Analysis

The Nestlé Company retained Bolt Beranek and Newman Inc. as consultants to evaluate the noise environment and recommend controls to ensure that all noise exposures in the area met OSHA limits. The highest worker noise exposure occurred at the filling machine operator location, where the sound level varied between 94 and 96 dBA. The sound level was at or above 92 dBA elsewhere throughout the space, because of the highly reverberant nature of the room (typical for food processing facilities where easy-to-clean, hard surfaces are required by FDA regulations). The filling machines were most responsible for the above-90 dBA sound levels, as the sound level dropped to 74 dBA when both filling machines were stopped.

To determine what part of the machines radiated noise, measurements were made close-in to suspected important noise sources. Observation of the operation indicated that likely candidates were the constant jar-to-jar contact at the infeed to the filling machine, the vibrations developed by the feed mechanism in the filling machine, and gear noise. Measurements were taken near each of these sources.

The data obtained appeared to confirm the significance of the suspected source. For example, the octave-band spectrum measured 6 in. from the filling machine inlet indicated that the sounds generated in that area were largely responsible for the octave-band sound pressure levels measured at the operator's ear, at least for those octave bands that penetrated the 90-dBA criterion curve appropriate for this situation. Figure 6.31.1 summarizes these findings. Note the similarity in spectral shape between the upper two curves. Other close-in measurements indicated that openings in the bottom part of the filler structure were important contributors to the overall noise environment relative to the 90-dBA criterion, but were of lesser significance than noise sources on the filler table itself.

The analysis suggested that the most significant noise was generated by jar-to-jar and jar-to-machine impacts. Clearly, a possible remedial solution would be to minimize or eliminate the force of these impacts. However, an equally acceptable acoustical treatment would be to contain the sounds. In view of the problems inherent in redesigning the machine feed mechanism to yield softer impacts, strong consideration was given to noise containment. In fact, the solution attempted was a cover for the infeed and discharge parts of the machine, combined with a closure for the bottom parts of the machine.

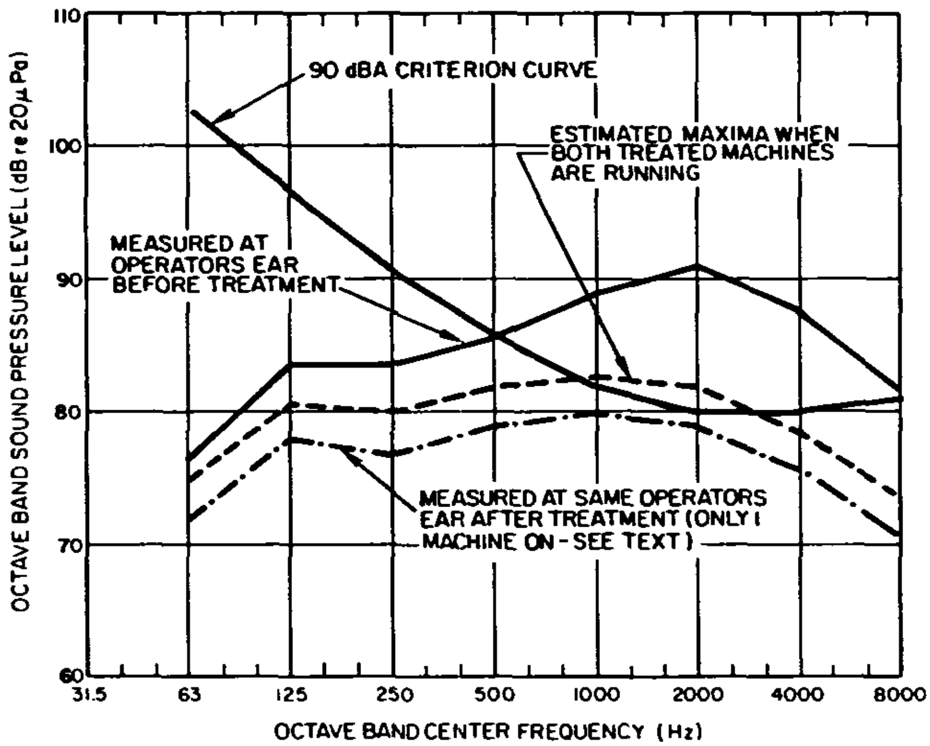

Figure 6.31.1. Sound pressure levels in filling machine room before and after treatment.

Control Description

Because of the intricate design of these machines, the selected noise control was not attempted until after a careful analysis had been made of the possibility of rotating filler-associated personnel with workers in other departments who were exposed to equivalent sound levels lower than 90 dBA. However, such rotation was discarded as totally infeasible.

The major problem associated with this project was the amount of design work needed. Mr. John Meyer, the design engineer, spent approximately 3 weeks on-site before sufficient details were gathered and design concepts fully developed. The design phase was also extended because of the constraints of sanitation, maintenance, and operator access.

Figure 6.31.2 is an example of the conceptual design drawings that were developed in connection with this project. The treatments were fabricated by the E.A. Kaestner Company of Baltimore, Maryland.

Excluding engineering design costs but including material and fabrication cost, the treatment for the two filling machines was $16,300.

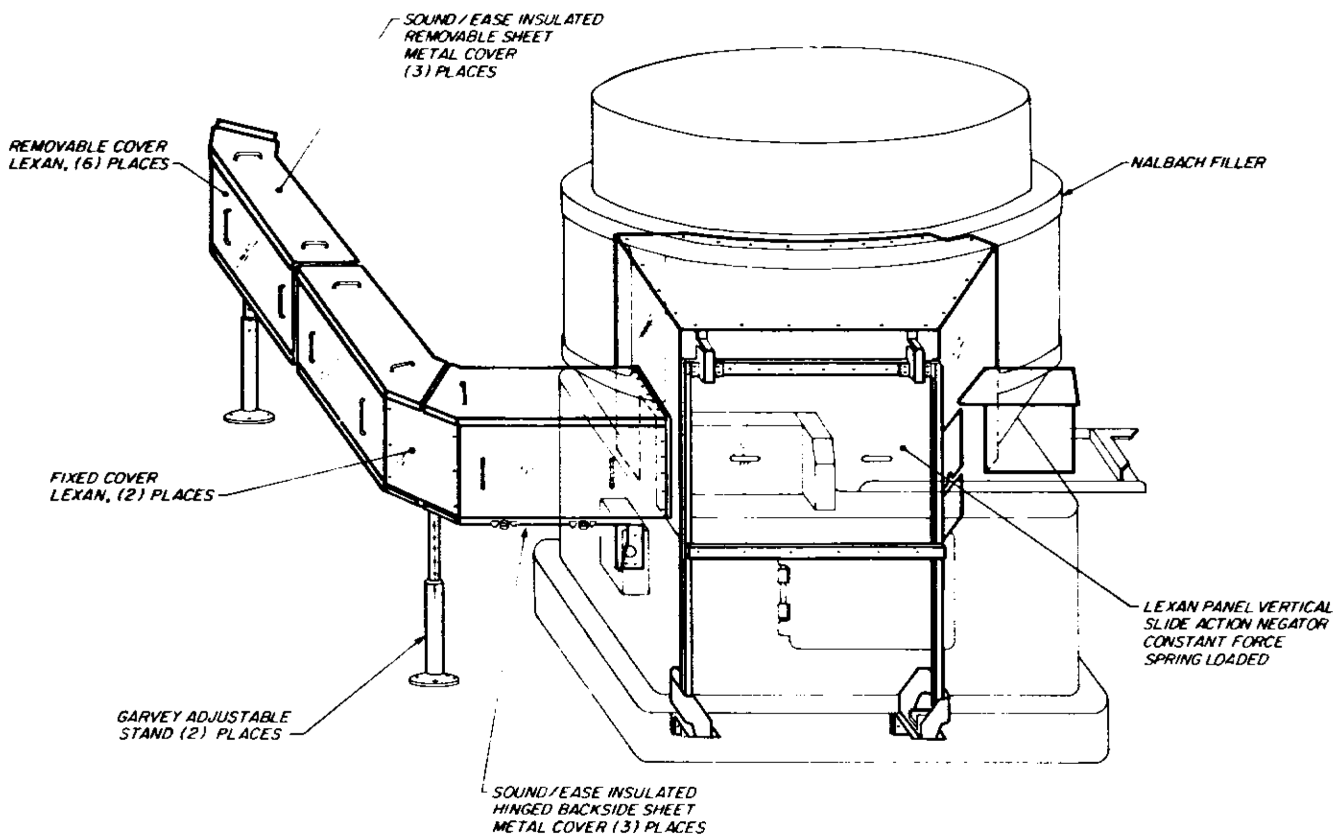

Figure 6.31.2. Example of the conceptual design drawings.

Results

Before treatment, the sound level at the filling machines was 94 to 96 dBA, when both fillers were running. Although after-treatment octave-band measurements were not available for the identical running modes, they exist for the condition with one filler running. For the one-filler-running mode, the sound level has decreased to 85 dBA. Figure 6.31.3 shows octave-band spectra of the measured before-and-after situations and an estimate of the maximum expected sound pressure levels for the two-filler-running mode. All operators are now exposed to sound levels less than the 8-hr 90-dBA level allowed by OSHA.

Operators and plant management indicate complete satisfaction with the controls, as sound levels have been reduced with no perceptible effect on productivity or product quality.

Comment

Dr. Carey discusses the conflict between FDA sanitation and OSHA noise reduction requirements in the July 1978 issue of *Sound and Vibration* in an article entitled "The Ramifications of Noise Control in Food Plants."

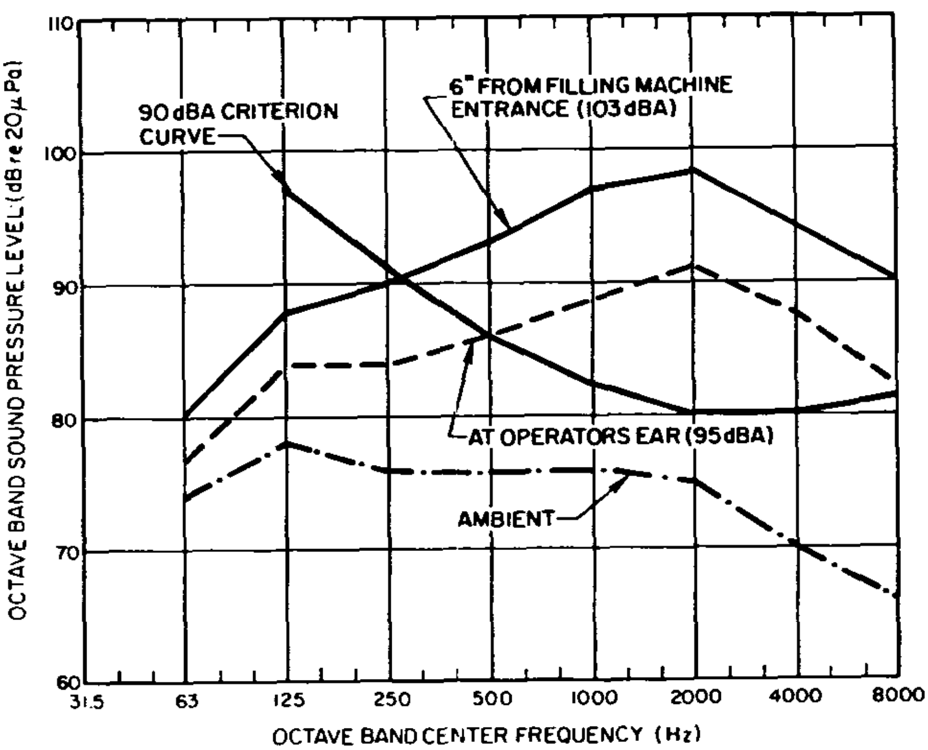

Figure 6.31.3. Sound pressure levels in filling machine room.

CASE HISTORY 32: GEARBOX
(Hearing Conservation Noise Problem)

Industrial Acoustics Co.
1160 Commerce Ave.
Bronx, New York 10462
(212) 931-8000

Problem Description

In this case history, the problem concerned engine room noise aboard the Matson Navigation Company's vessel *Hawaiian Queen.* At full power, the 9000-shp steam turbine used aboard the ship causes sound levels exceeding 120 dBA in the engine room.

Problem Analysis

Investigation of the noise problem showed the cause of the high levels to be the primary stage of a nested-type double reduction gear unit. Sound levels are considerably lower when this unit is not operated. Although consideration was given to replacing gearing, that alternative was rejected because of the expense involved, in favor of enclosing the reduction gear casing. An enclosure design was sought to bring the engine room noise environment down to ambient levels measured when the gear unit was inoperative. The required noise reduction is indicated in Figure 6.32.1, which also compares sound pressure levels measured in the engine room with and without the gear unit in operation. The required noise reduction is the algebraic difference between the two curves.

Control Description

IAC Modular(TM) acoustic panels were used as the basis for the enclosure because of the high transmission loss properties. A notable feature of this enclosure is the use of a split commercial silencer at the propeller shaft penetration into the enclosure, to attenuate sounds that would otherwise escape around the shaft. Penetrations for thermocouples, lubricating oil lines, and other pipes were cut in the enclosure and provided with seals. Materials for a similar enclosure would cost about $9000 today.

Results

The actual effectiveness of the enclosure is not measurable because after the enclosure was put in place, the engine room noise environment decreased to the ambient levels. However, it is clear that the enclosure met design objectives.

The major problem with the enclosure was rearrangement of piping necessitated by close tolerances between the gearbox casing and the enclosure walls.

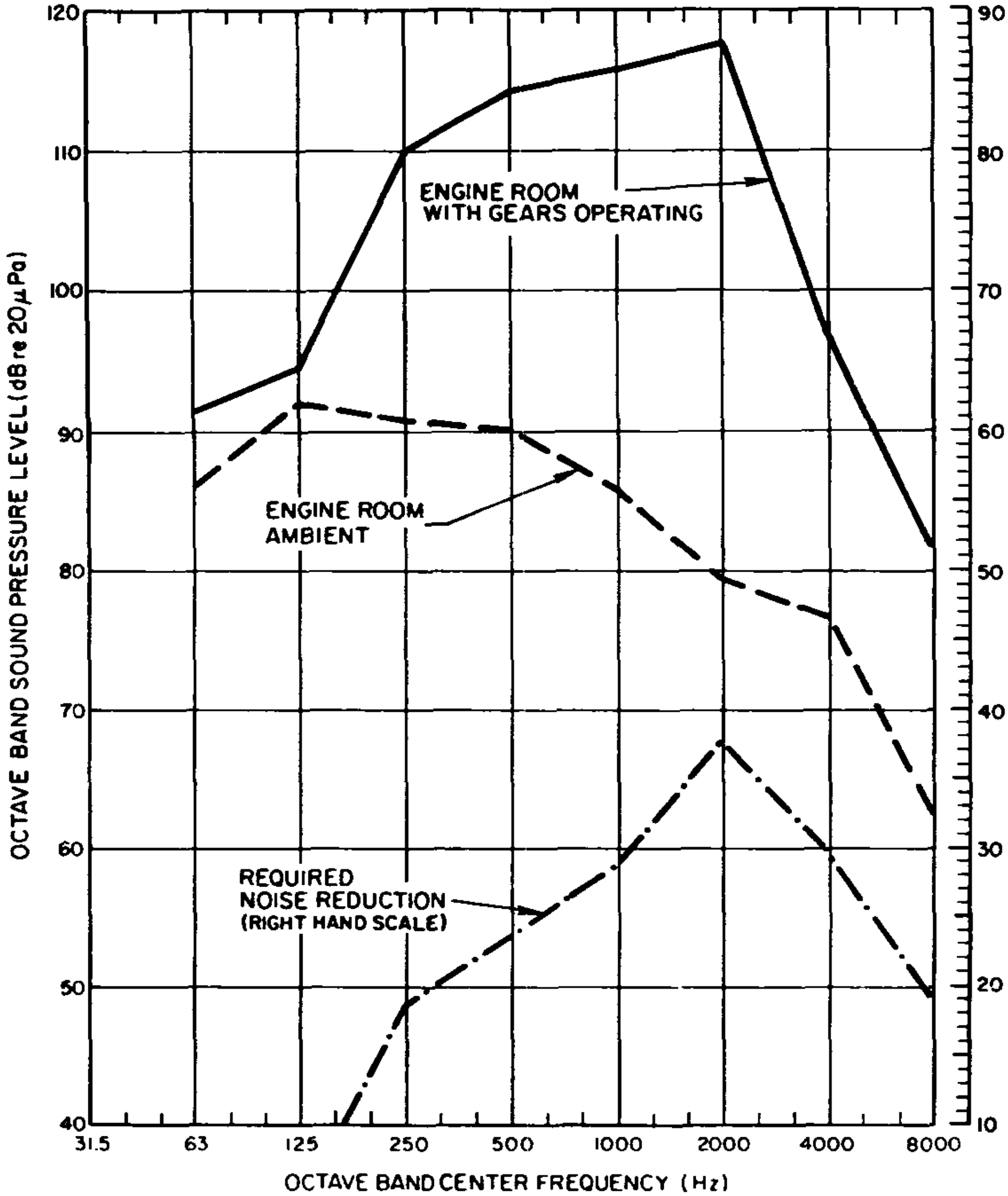

Figure 6.32.1. Engine room sound pressure levels.

The operating temperature of the gearbox did not change as a result of its enclosure.

Note that in most cases of enclosure construction, achieved noise reduction obtained probably will not reach the amount indicated by the given laboratory-determined transmission loss of the enclosure walls. The reason is that when an enclosure is made, noise is confined, resulting in a build-up of sound levels inside the enclosure. This effect is predictable when the principles of room acoustics, described in Noise Control Analysis, are used. In this case, however, the use of nonreflective panels for the enclosure walls minimized the effect.

CASE HISTORY 33: STEAM GENERATOR FEED PUMP
(OSHA Noise Problem)

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Bolt Beranek and Newman Inc.
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Cambridge, Massachusetts 02138
(617) 491-1850

Steam generator feed pumps are generally considered to be one of the principal sources of high sound levels inside electric power plants. This case history describes the noise control work associated with two boiler feed pumps at a coal-fired electric power plant. This work was a part of an overall program to reduce employee noise exposure throughout the plant.

Problem Description

Employees at electric power plants sometimes work near machinery that produces high levels of noise. An electric utility retained Bolt Beranek and Newman Inc. to study the employee noise exposure in one of the utility's large fossil-fueled power plants. As a result of this study, several major noise sources were identified. Noise control treatments were designed for these sources to reduce sound levels to less than 90 dBA in the frequently occupied areas of the plant. The problem described in the following case history is that of designing and installing acceptable enclosures for the boiler feed pumps.

The two boiler feed pumps for this station are located on the operating level of the turbine building. The pumps' design load at 5600 rpm is 7000 gpm with a discharge pressure of 4400 psig and water temperature of 330°F. Each pump is driven by a 21,000-hp steam turbine.

The pumps produced a high level of tonal noise. The pump tone was within the 1000-Hz octave band and, because of its high level (100 to 105 dB near the pump), it controlled the A-weighted sound level throughout the turbine hall.

Problem Analysis

The owner of this plant had decided to study the feasibility of reducing plant sound levels to less than 90 dBA in all frequently occupied areas and to adopt this sound level as a design goal for noise control treatments. The turbine hall is a frequently occupied area of the plant and, because of the boiler feed pump, the sound levels varied from about 92 to 98 dBA.

Other noise sources in the turbine hall – beside the boiler feed pumps – included the pumps' drive turbines, the main turbine, the main generator, and the exciter. Narrowband analysis of the noise throughout the turbine hall indicated that the boiler feed pump tone controlled the A-weighted sound level at almost all locations. Further analysis indicated that if the level of pump noise and its tone could be adequately reduced, the sound levels throughout the turbine hall would be about 90 dBA or less.

On the basis of a careful analysis of the narrowband data and a subjective analysis (listening to the sound in the turbine hall), it was determined that only the boiler feed pumps required treatment. Many close-in measurements and tape recordings were made near the pump. Analysis of these data indicated that the tonal noise was radiating strongly from much of the pump surface.

Three types of noise control treatments could be considered for this pump:

(1) Acoustical lagging applied to the exterior surface of the pump. This treatment has been applied to boiler feed pumps with some limited success. It has been found difficult, however, to design and construct a well-isolated complete lagging treatment that can be easily removed and replaced during pump maintenance.

(2) Modification of the pump flow path was considered a possible alternative. Discussions with the pump manufacturer indicated that a reduction of 6 dB to 10 dB might be obtained and that the manufacturer could perform the necessary machine work on the impeller at their shop. The owner was somewhat concerned about modifying his pump because of a potential reduction in pump performance and also because of required down time. (Outages at a power plant can cost up to $100,000 per day.)

(3) Enclosures for the pumps could provide the necessary insertion loss. Difficulties related to this approach included the safety of personnel inspecting the pump inside the enclosure, ventilation of the enclosure, and easy removal/replacement during pump maintenance.

Control Description

A complete enclosure was designed for each pump. The enclosures are about 19 ft × 19 ft × 10 ft high and include several sections easily removed by the existing overhead crane. Three gasketed doors, each with a window, are included to ensure that a worker would not be trapped if a high-pressure steam leak developed while he was inside the enclosure. The walls and roof are constructed of 16-gauge sheet steel outer surface, 4-in.-thick glass fiber insulation, and 22-gauge perforated sheet steel inner surface. Several penetrations of the enclosure were necessary for lines, drive shaft, etc. The penetrations were small, and they were sealed where possible. Interior lighting was provided, as was a temperature monitor.

Ventilation of the enclosure was also provided to reduce the build-up of heat. Some difficulties have been experienced in this area. During the summer months, the temperature within the enclosure reached 125°F. While this heat does not affect the pump, it is uncomfortable for a worker inspecting the pump. It is expected that a modification of the ventilation system will correct this heat build-up problem.

Results

The owner is pleased with the results obtained with the enclosures for these two pumps. Sound levels throughout the turbine hall have been reduced from the previous levels of 92 to 98 dBA down to the present levels of 88 to 89 dBA. The sound in the turbine hall is generally broadband and controlled by other sources. Octave-band sound pressure levels measured several feet from the enclosure are shown in Figure 6.33.1 and are compared to measurements made before the enclosure was installed. The enclosure insertion loss is at least 19 dB in the 1000-Hz octave band that contained the pump tone. The measured insertion loss shown in this figure is limited by noise from other sources. It is clearly shown that the tonal character of the sound has been reduced, the A-weighted sound level has been reduced to less than 90 dBA, and the speech intelligibility for this area has been improved.

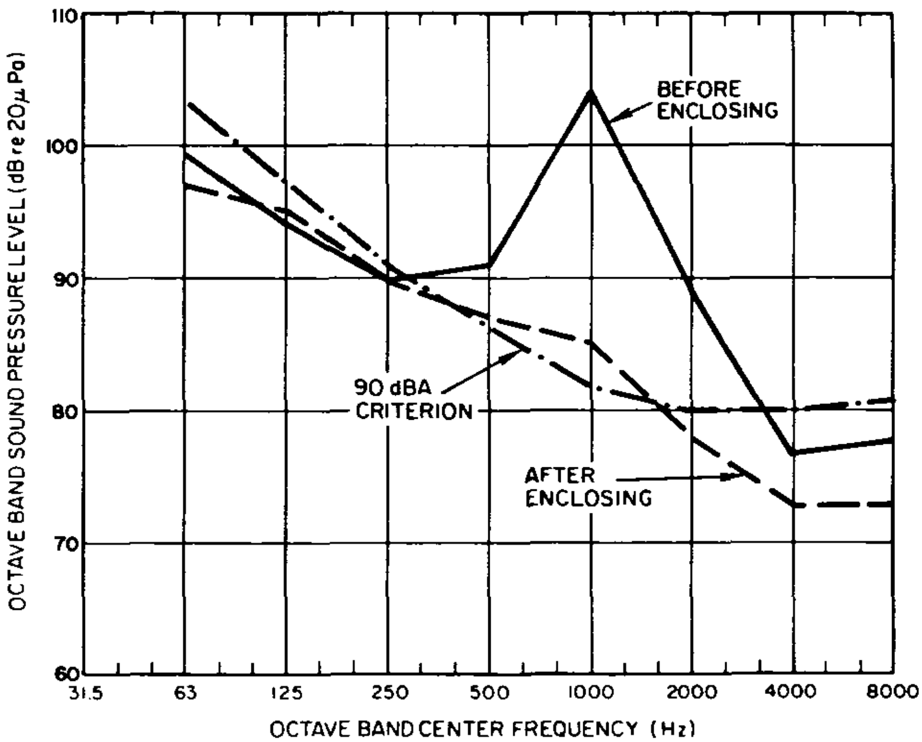

Figure 6.33.1. Measurements near boiler feed pump.

Plant workers were somewhat concerned about the effects this enclosure would have on pump accessibility during maintenance work. Since installation, however, the enclosure has been removed twice and reinstalled without difficulty. Removal time in both cases was less than 20 min.

It is often important to contact the equipment manufacturer prior to enclosing his equipment. His advice and experience can lead to improved designs. Discussions with in-house maintenance, safety, and operating personnel are essential.

CASE HISTORY 34: MUFFLER SHELL NOISE
(Community Noise Problem)

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Mufflers for equipment such as internal combustion engines, compressors, and vacuum pumps can effectively reduce inlet and exhaust noise. However, the muffler shell and associated ducts can themselves be effective radiators of noise and may require additional treatment so that the muffler can perform up to its potential. This case history discusses a complete enclosure built around a vacuum system exhaust muffler to reduce sound levels in the nearby community.

Problem Description

Fourteen vacuum pumps are used to extract exhaust gases from an engine test cell when experiments are to be conducted at low-pressure conditions. These pumps discharge to a common 48-in. duct that leads to three low-frequency mufflers connected in parallel and grouped together outside the test facility building. When the vacuum pumps are operating, a distinctive tonal noise can be heard beside the mufflers and at some distance from the facility. The amplitude of this tonal noise varied slowly in level with a fairly regular period of about 10 sec. These pumps were operated only while other noisy sources were also operating. However, the distinctive character of the pump noise was helpful in determining its contribution to total plant noise in the community.

Each muffler was cylindrical in shape, 16 ft long and 5 ft in diameter, and thus had a large surface area to radiate sound. The mufflers were also on a nearly direct line-of-sight to the community near the plant. Each muffler also had a single 30-in. vertical discharge duct that extended to a position 35 ft above ground elevation.

The purpose of the overall noise control program was to reduce the plant sound levels to less than that stipulated by the city ordinance. For the vacuum pump discharge, it was necessary to determine (1) its contribution to the total noise from the plant, (2) the required insertion loss, and (3) whether the required insertion loss could be obtained by treating only the muffler discharge or only the muffler shell, or both together.

Problem Analysis

The city noise ordinance limits nighttime industrial noise to 55 dBA at residential boundaries. Continuous measurements of the ambient sound at the nearest residential boundary (i.e., with the plant shut down) indicated that the ambient sound was often greater than 55 dBA. It was less than 55 dBA only about 30% of the time, during the quietest periods between 1 a.m. and 6 a.m. and without the plant operating. Because test rigs were planned to be operated later than 1 a.m., it was considered necessary to establish a plant design goal even more stringent than the ordinance, to avoid any possibility of community complaints.

An octave-band sound pressure level design goal is far more useful than a single-number sound level goal because the performance of noise control treatments is frequency-dependent. The octave-band sound pressure level design goal was chosen to have a shape similar to the spectrum of the plant noise and a sound level equivalent of 55 dBA. The design goal for the vacuum pump discharge system and the other plant sources investigated was then chosen to be 5 dB lower to account for simultaneous operation of several sources.

Measurements made near the muffler shell and near the discharge opening showed similar levels of noise. Vibration measurements made on the muffler shell and large intake duct showed high levels of vibration. A narrowband analysis of the shell vibration and farfield noise showed very similar tonal content – a fundamental frequency at 88 Hz and harmonics of this frequency up to 1000 Hz. The strong tone and its harmonics were the result of the 12 pump vanes rotating at a frequency of 435 rpm.

The interior of the muffler was inspected visually to confirm that no mechanical damage had occurred. On the basis of this inspection and the investigative measurements discussed above, it was concluded that the principal radiating area was the muffler shell – not the muffler discharge opening.

The sound pressure levels near the muffler and in the community are shown in Figure 6.34.1 and are compared to the plant design goal. The required reduction in sound levels is the amount by which the residential sound levels exceed the goal, plus an additional 5 dB to account for other sources. The reduction is 22 to 26 dB in the 63- and 125-Hz octave bands and 7 to 10 dB in the 250- to 1000-Hz octave bands.

Control Description

Three alternative noise control treatments were considered to provide the significant reduction required in the lower frequency octave bands:

(1) Lagging the muffler shells and intake duct with a thick isolation material and a heavy metal outer surface;

(2) Enclosing the mufflers and intake duct with a concrete wall lined with a sound-absorptive material;

(3) Enclosing the mufflers and intake duct with a staggered stud double wall with interior sound-absorptive material.

A lagging treatment was rejected in favor of an enclosure because of the inherent difficulties associated with providing adequate isolation and adequate support of the outer metal cover. The plant owner selected the double wall design rather than the concrete wall because of construction details at his plant.

The final construction design included a 24-gauge corrugated steel siding bonded to 1/2-in.-thick gypsum board supported on steel studs. The inner wall is separately supported on steel studs 5 in. from the outer wall. The inner wall consists of 1/2-in.-thick gypsum board and 4-in.-thick, 4 lb/ft^3 glass fiber board spaced out 2 in. from the inner wall. The 4-in.-thick glass fiber lining is provided as a sound-absorptive material to prevent the build-up of a sound within the enclosure. A fully gasketed acoustical-type 8 ft × 8 ft door is provided for access into the enclosure.

Results

The insertion loss of this enclosure has not been measured. The plant owner has, however, indicated that the vacuum pump system discharge is now nearly inaudible at a distance from the new enclosure. The pump system noise has been reduced to the point where it is masked in the community by other sources at the plant. The overall plant noise reduction program is still underway — the vacuum pump exhaust system was one of the first plant sources to be treated.

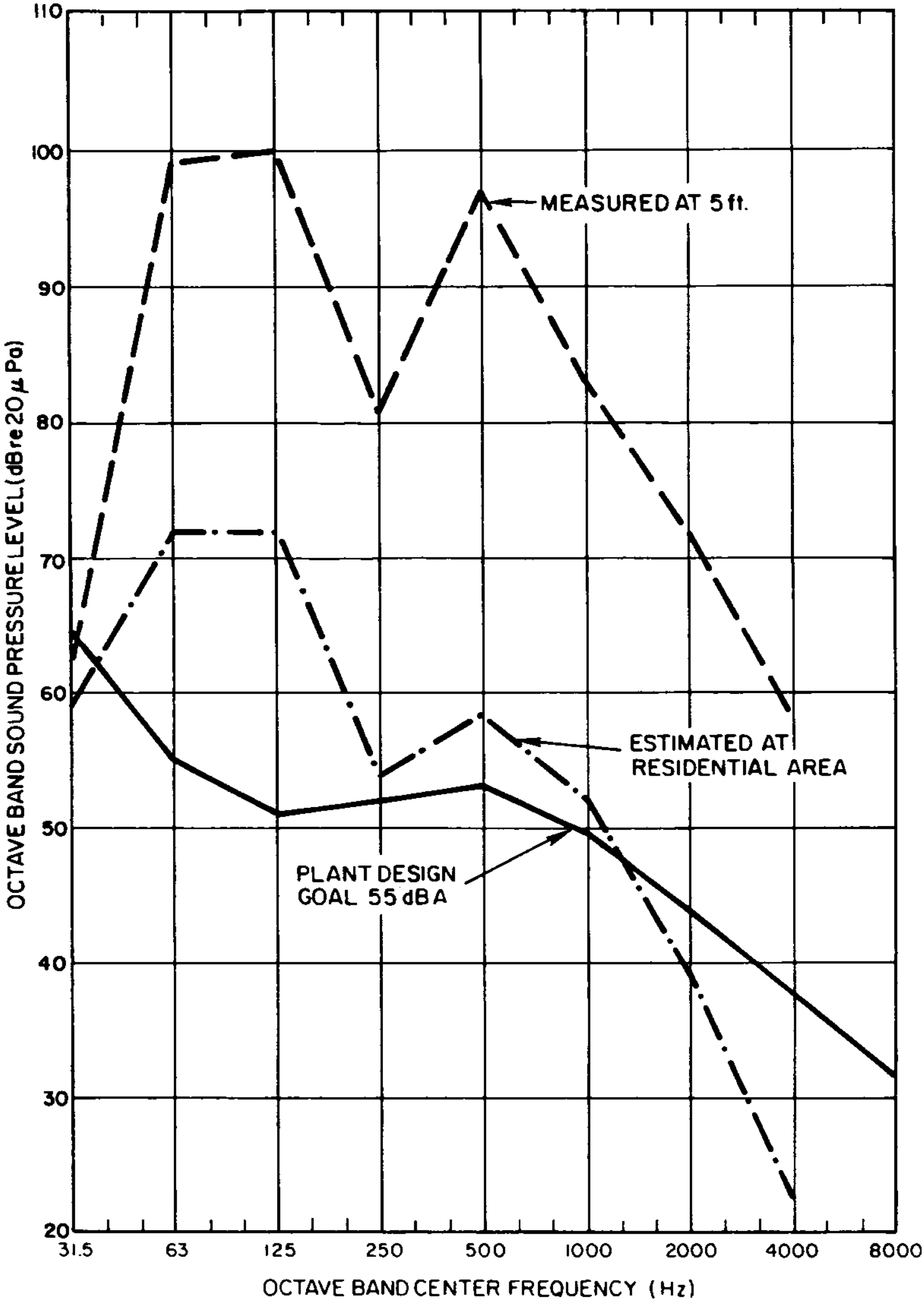

Figure 6.34.1. Vacuum sound pressure levels and residential criterion.