ILLINOIS EPA
Environmental Protection Agency
1701 First Avenue, Maywood, IL. 60153

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STATE OF ILLINOIS
POLLUTION CONTROL BOARD

312/345-9780

January 20, 1984

PC# 1

Ms. Christian Moffett, Clerk
Illinois Pollution Control Board
309 West Washington, Suite 300
Chicago, Illinois 60606

Re: PCB #R83-32

Dear Ms. Moffett:

Enclosed is the Agency's response to the subject request for a site-specific allowable operational level. Please enter this into the public record.

Sincerely yours,

Major Hearn, Jr.

Major Hearn, Jr., Asst. Mgr.
Field Operations Section
Div. of Land Pollution Control

MH:pgb

cc: File

Written by: Major Hearn, Jr.
Date: January 20, 1984

R83-32
Site Specific Operational Level
Request by VAUGHN & BUSHNELL MANUFACTURING COMPANY
Bushnell, Illinois

The Vaughn & Bushnell Manufacturing Co. states in its petition that it has been situated at its present location since 1940. Thus, it clearly qualifies as an "existing impact forging operation." The Agency has no data to refute the petitioner's claim that its present operation emits noise in excess of the numerical limits of Rule 206(c) of Chapter 8 of the Board's rules and regulations. In addition, the Agency does not have the manpower to conduct the necessary sound surveys to substantiate this claim. However, since the Vaughn & Bushnell Manufacturing Company operation appears to be typical of the impact forging operations in Illinois, and since typical impact forging operations in this State have been found to emit noise in excess of the numerical limits of Rule 206(c), we have no reason to doubt the petitioner's claim.

The Agency has never received citizen complaints about noise emissions from the Vaughn & Bushnell Manufacturing Company. Thus, the Agency has never recorded sound data on residential property near the petitioner's facility. The petitioner states that "the estimated worst case emission measured at the closest Class A land is 65 L_{eq}". The Agency has no reason to challenge this claim, and the 65 L_{eq} level exceeds the numerical limits of Rule 206(c).

An important consideration in determining whether or not the petitioner is eligible for a site specific allowable operational level is the ability/inability of the facility to reduce its noise emissions to within the limits of Rule 206(c). The Noise Project Task Force sponsored by the Forging Industry Educational and Research Foundation (FIERF) studied the forging noise problem and concluded, "to the date of this guideline (March, 1977), there is no feasible method of controlling impulse noise emissions from forge hammers at the source, nor is there one within sight." The FIERF Task Force further concluded that sound energy radiated from forge hammers to the surrounding neighborhood can be reduced through "acoustical strengthening" of the forge shop structure such as replacing metal roof decks with decks containing asbestos materials, replacing sheet metal walls with brick or concrete blocks and replacing plain glass windows with double glass windows. In addition, the size of ventilation openings in forge shops can sometimes be reduced to provide noise reduction in the area of "3 dB(A) per area halving", and sound radiated from ground level openings can be reduced by erecting free standing barriers to provide sound reduction in the range of 5 to 15 dB(A). The barriers should have no openings, should have a surface density of at least 4 lbs/ft^2 and the inside face should be covered with a sound absorptive material. The cost of such a barrier was estimated by the Task Force to be approximately $5.95 per square foot. (See Exhibits #1 & #2).

Another method of reducing impact noise emissions from forge shops is the addition of duct silencers for ventilation openings. Such silencers consist of alternating layers of free air space and sound absorbing material. The silencers range in price from $22.50 - $46.00 per square foot, and provide attenuation from 15 - 36 dB(A). However, such silencers constrict air flow and they cannot be used in forge shops where air flow is already at a minimum level. (See Exhibits #1 & #2)

Finally, noise emissions to the surrounding neighborhood from forge hammers can be reduced by installing gravity ventilators on roof openings. Gravity ventilators are of more complex construction then natural draft roof openings, and they have surfaces which reflect the sound back to reduce the radiated noise. (See Exhibits #1 & #2)

All of the above-outlined noise abatement measures must be considered on a site-by-site basis. Although the use of each measure will bring about noise reduction, each measure might also result in obstruction of air flow in the forge shop and/or obstruction of passage ways witnin the shop.

According to the site-specific operational level petition filed by the Vaughn & Bushnell Manufacturing Co., the existing forge shop buildings have structural limitations, space requirements and ventilation demands that make the implementation of the above-outlined noise abatement measures extremely difficult and prohibitly expensive. Although the petition contains no cost figures, the Agency has no reason to doubt the validity of the petitioner's assertion.

The petitioner states, "... ventilation essential to a safe operation, especially during summer months, necessitates that virtually the entire perimeter be open in order to generate sufficient air flow to the work area." The use of gravity ventilators, duct silencers and any reduction of the ventilation openings in the building would reduce air flow to the work area. Thus, the use of these measures to reduce noise emissions from the petitioner's forge shop is questionable. In addition, the petitioner states that "additional mechanical ventilation cannot be placed on walls or roofs, or hung from beams without altering the existing load-carrying capacities".

Since the Vaughn & Bushnell Manufacturing Company plant is typical of forge shops built in the early 1900's, and those froge shops typically were not constructed to support the weight of the modern wall treatments and ventilation devices, the Agency has no reason to doubt this claim.

The Vaughn & Bushnell Manufacturing Co. petition states that there are "50 residences potentially exposed to sound levels in excess of the night-time standard of 53.5 L_{eq}". According to I.S.O. Recommendation R1996 (Assessment of Noise With Respect to Community Response), community response to the 53.5 L_{eq} noise level would range from "none - no observed reaction" to "little - sporadic complaints". I.S.O. Recommendation R1996 indicates that community response to the 65 L_{eq} noise level should range from "strong - threats of community action" to "very strong - vigorous community action".(See Exhibit #3)

The U.S.E.P.A. document "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety" states, "It is difficult to identify a single-number limit requisite to protect against adverse effects from impulse noise because it is essential to take into account the circumstances of exposure, the type of impulse, the effective duration, and the number of daily exposures". The "Levels Document" goes on to conclude, "Review of temporary threshold shift data leads to the conclusion that the impulse noise limit requisite to prevent more than a 5 dB permanent hearing loss at 4000 Hz after 10 years of daily exposure is a peak sound pressure level (SPL) of 145 dB. This level applies in the case of isolated events, irrespective of the type, duration, or incidence at the ear. However, for duration of 25 micro-seconds or less, a peak level of 167 dB SPL would produce the same effect". The "Levels Document" further concludes, "impulses exceeding the background noise by more than about 10 dB are potentially startling or sleep-disturbing. If repeated, impulsive noises can be disturbing to some individuals if heard at all ----. However, no threshold level can be identified at this time; nor is there any clear evidence or documentation of any permanent effect on public health and welfare". (See Exhibit #1)

Using the informtion concerning health effects provided by the "Levels Document", if a 65 L_{eq} operational level is granted for the Vaughn & Bushnell Manfacturing Co. facility, area residents exposed to the noise would not be in any danger of experiencing hearing loss.

In Summary:

I. The Agency does not challenge the Vaughn & Bushnell Manufacturing Company's qualification for a site-specific allowable operational level on the basis that it is an "existing impact forging operation."

II. The Agency has no reason to doubt that the subject impact forging operation emits noise in excess of the limits of Rule 206(c).

III. Although technically feasible noise reduction measures for forge shops exist, we believe that these are not technically feasible nor economically reasonable to reduce noise emissions from the Vaughn & Bushnell Manufacturing Company.

IV. If a 65 L_{eq} site-specific operational level is granted, I.S.O. Recommendation R1996 indicates that community reaction to the noise would range from "strong - threats of community action" to "very strong - vigorous community action". The inhabitants of the 50 residences potentially exposed to sound levels in excess of "53.5 L_{eq}"should have a response ranging from "none - no observed reaction" to "little - sporadic complaints".

V. If a 65 L_{eq} site-specific operational level is granted, the U.S.EPA "Levels Document" indicates that there would be no danger of hearing loss to area residents.

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EXHIBIT #1

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Methods for Neighborhood Noise Control

The noise control methods outlined here are directed towards reducing the sound energy radiated to the neighborhood through acoustical "strengthening" of the forge shop structure.

Ventilation openings are almost always the building elements through which most of the sound energy is radiated. The application of control methods must take into account the effects on ventilation concurrently. The controls are as follows:

1. Reduce the Opening Size: (noise reduction is 3 dBA per area halving)

Sometimes the vent openings in forge plants are much larger than they need be — especially if the plant has an open roof — and significant reductions in the neighborhood noise level can be made fairly simply by partially closing steel doors over the vent openings. Broken and open windows can be replaced and closed; windows higher, about 8 feet from the shop floor, do not help the ventilation of the work area and may even detract from it.

2. Shield the Lower Wall Openings With a Free Standing Wall

The sound radiated from ground level openings can be reduced by a free standing wall as shown in Figure V.10. The sound reduction available practically is in the range of 5 to 15 dBA. For example, if H = 4 ft and R = 20 ft, then the noise reduction at a distant neighborhood point would be about 10 dBA. The barriers should have no openings, should have a surface density of at least 4 lbs/ft^2 and the inside face should be covered with a sound insulating material, e.g., 1 1/2" plastic wrapped fiber glass.

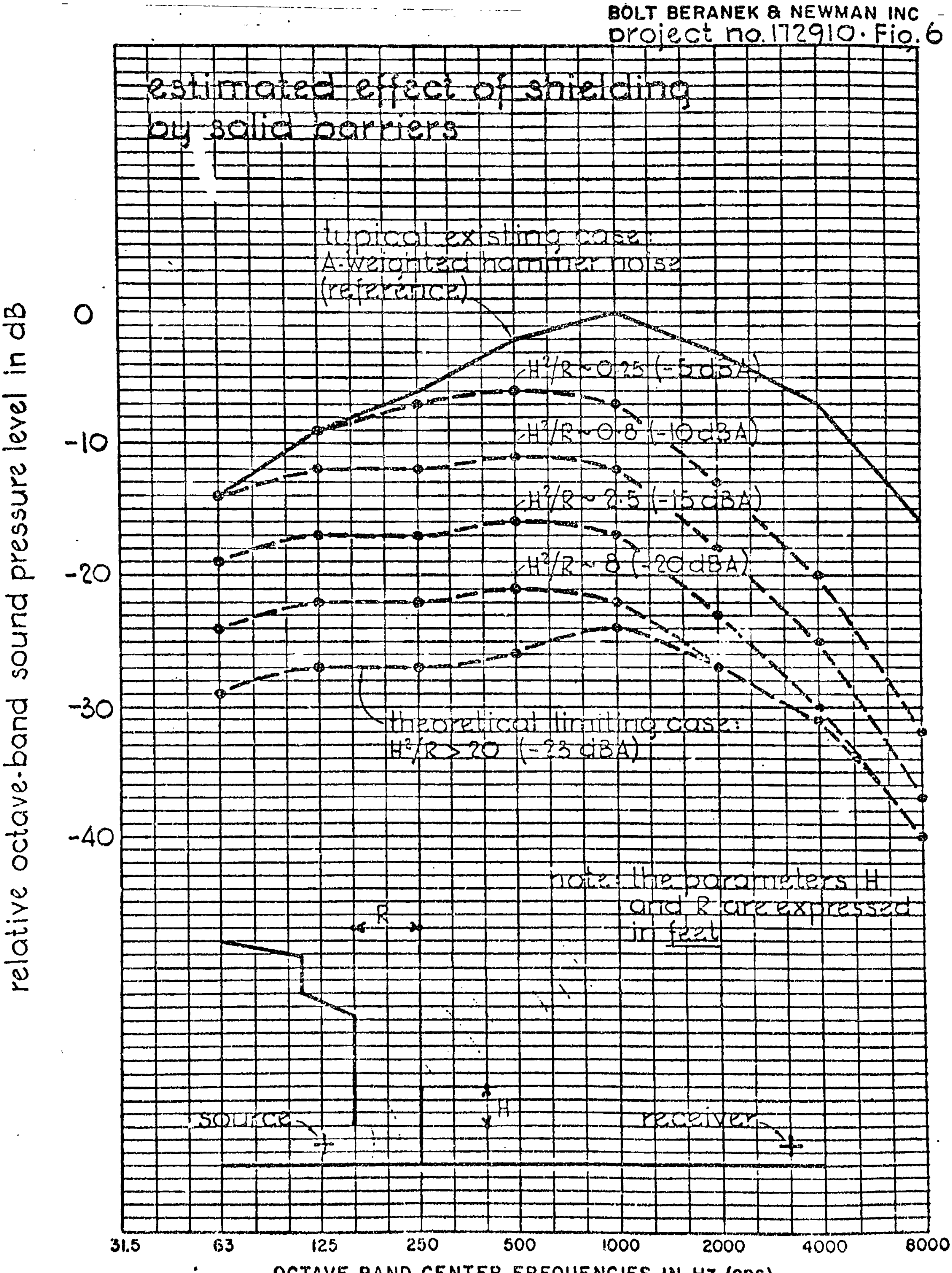


Figure V.10. Estimated Shielding Effects of Free Standing Walls Near Lower Wall Openings.

Table V.8 gives the estimated costs for 4 types of free standing shield walls:

TABLE V.8. Estimated Costs for a Free Standing Shield Wall*
210' x 10'7" = 2226 sq.ft.

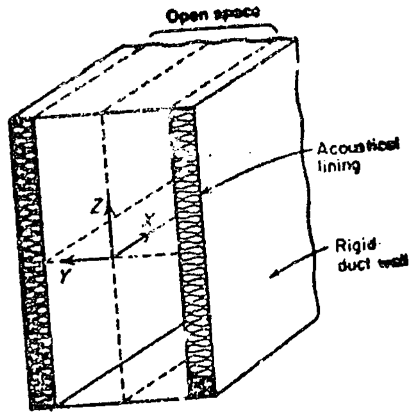
	Reinf. Conc. Ftgs. @ 10' o.c.	=	$ 2.25/sq. ft. wall		
	Struc. Steel Frame	=	3.70		
	Struc. Frame + Found.		5.95/sq. ft. wall		
	1" wood T. & G.		1.50		
	Inryco Acoustiwall -L-21		4.00		
(1)	Total with 1" wood = 2226 sq. ft. @		$11.45/sq. ft.	=	$25,488
	Str. Frame + Found.	=	$ 5.95/sq. ft.		
	"Acoustiwall"		4.00		
	3/8" Asbestos Cem. Board Siding =		1.40		
(2)	Total with Asbestos Cem. Siding 2226 sq. ft. @		$11.35/sq. ft.	=	$25,262*
	Struc. Frame & Found.		5.95/sq. ft.		
	"Acoustiwall"		4.00		
	Sht. Steel Siding		2.00		
(3)	Total with Sht. Steel Siding 2226 sq. ft. @		$11.95/sq. ft.	=	$26,600
	Struc. Frame & Found.		5.95/sq. ft.		
	"Acoustiwall"		4.00		
	Masonry Wall (8" C.B.)		3.00		
(4)	Total with Masonry Wall 2226 sq. ft. @		$12.95/sq. ft.	=	$28,826

* from reference 13. There may be other types that cost less.

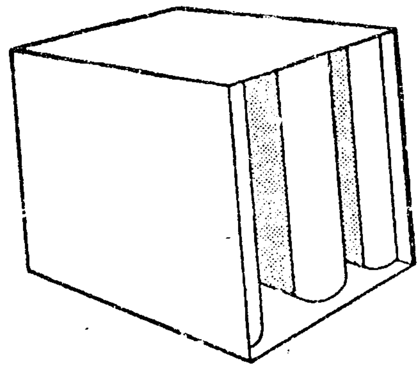
3. Apply Duct Silencers to the Openings

Silencers consist of alternating layers of free air space and sound absorbing material as shown in Figure V.11.

Figure V.11. Rectangular Duct Silencers for Ventilation Openings. (A) is a Schematic Sketch and (B) is a Sketch of a Commercial Silencer (Korfund Dynamics Corp.). (The Silencer Face Area is the Open Area plus the Acoustical Lining Area).



(A)



(B)

Two types of ratings for silencers are important — their acoustical performance as measured by insertion loss and their aerodynamic performance as measured by their pressure drop characteristics. Table V.9 gives these for silencers from a particular manufacturer.

TABLE V.9

SILENCERS FOR VENTILATION OPENINGS

Selection Data:

Attenuation	Pressure Drop in H_2O @ 4 ft./sec.	Pressure Drop in H_2O @ 8 ft./sec.	Cost/ft.*2	Silencer Type
15 dBA	0.0027	0.0107	$22.50	36 LP
20 dBA	0.0037	0.0145	34.00	60 LP
25 dBA	0.0082	0.0330	34.00	60 MP
32 dBA	0.0115	0.0450	46.00	84 MP
36 dBA	0.0280	0.1050	46.00	84 SP

* Cost does not include installation - 1975 prices.

(Courtesy of Korfund Dynamics Corporation)

The insertion loss refers to the noise reduction that will be measured on placing a silencer in a duct (where there had been none before). The situation in which silencers are applied to attenuating sound radiated from forge shops is somewhat different but the noise reduction will again be about equal (or a few dB less) to the insertion loss. If for example, it was found that a lower wall opening contributed 76 dBA at a neighborhood point, placing 15 dBA silencers in the opening should reduce the noise level at the neighborhood point by 12 to 15 dBA.

The pressure drop characteristics of silencers rate their constricting effect on air flow. This is especially important for natural draft ventilation in which pressure drops must be limited to only about 0.01 inches of water. It is not possible to use silencers with insertion losses larger than about 25 dBA with natural draft ventilation. In silencer application, the face area of the silencer will exceed the open area required to provide a given air volume as given in Table V.10 below.

TABLE V.10. The Approximate Ratio the Silencer Face Area to Open Area Required to Provide a Given Air Volume.

Silencer Insertion Loss	Silencer Face Area/Open Area
10 dBA	≈1
15 dBA	1.2
20 dBA	1.6
30 dBA	2.0
40 dBA	4.0

Silencers, especially in the high insertion loss range are very expensive and their use should be weighed carefully against the alternatives. Silencers are available from a number of firms including:

Burgess Industries
Environmental Group
8101 Carpenter Freeway
Dallas, TX 75247
214/631-1410

Korfund Dynamics Corp.
P.O. Box 235
Cantrague Road
Westbury, NY 11590

4. Gravity Ventilators on Roof Openings

In natural draft ventilation, a roof opening is required to exhaust the heated air from the forge plant; the roof opening must be fairly large and is usually one of the most important contributors to the neighborhood noise level. Many forge plants utilize a simple open roof in which two halves of the skylight are raised to form a clear sound path to the outside. A roof ventilator is of more complex construction; it has internal surfaces which reflect the sound back to reduce the radiated noise. The attenuation of a roof ventilator is in the range of 8 to 15 dBA depending on the construction. For example, sound absorbing material placed on internal reflecting surfaces of the ventilator will reduce the transmitted sound.

Figure V.12 shows a simple open roof (courtesy of A. Finkl & Sons) and a gravity ventilator manufactured by H. H. Robertson Co., 400 Holiday Drive, P.O. Box 16212, Pittsburgh, PA 15242 (412/922-9300). Gravity ventilators are also manufactured by the Burt Manufacturing Co., Akron, OH. The cost of the ventilators depends on their size and are best obtained by calling the manufacturer.

Acoustical Strengthening of Wall, Roof Coverings as Sound Barriers

If sound radiation from building openings is effectively controlled, the noise level in the neighborhood can be determined by radiation through wall and roof coverings. This is especially true if the covering materials are light, e.g., 26 gauge corrugated steel.

The sound radiation through an element can be reduced by increasing the transmission loss of the element covering material (see Table V.4 for some transmission loss data). For single layers of a material, the transmission loss will increase with the surface mass density, roughly 4.5 dBA per surface density mass doubling. Composite walls (material layers separated by an air space) will not follow the mass law if the separation of the layers is less than one foot; the transmission loss will exceed that predicted by having twice the mass density in a double wall. For hammer noise, the transmission loss of a double wall will exceed that based on surface mass density depend-

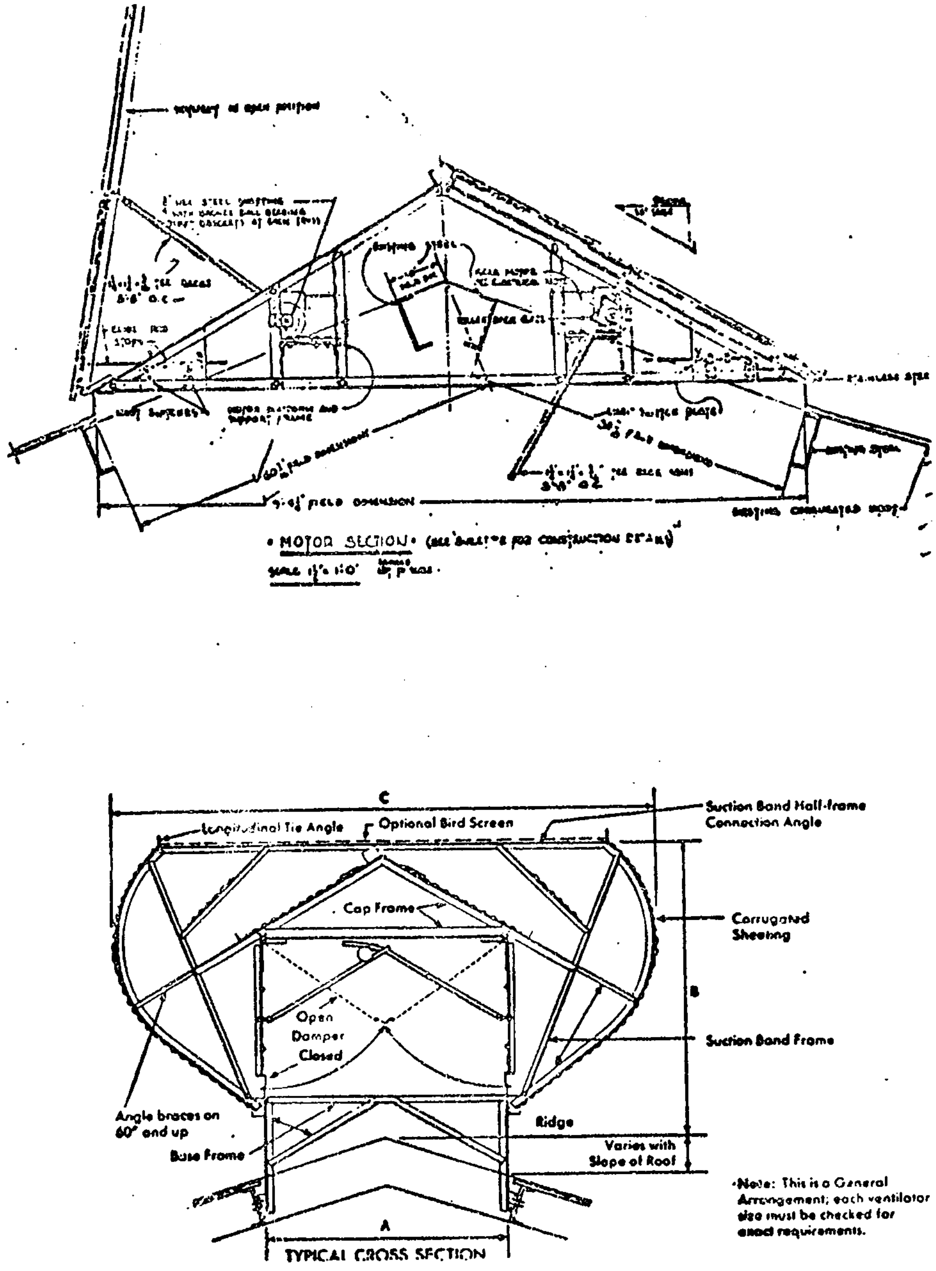


Figure V.12. Simple Open Roof (top — courtesy of A. Finkl & Sons) and an Open Roof Ventilator (H. H. Robertson Co.).

ing on the separation; for a 1 1/2" air space add 4 dBA, 3" air space add 8 dBA and a 6" air space add 12 dBA.

There are numerous commercial sound barrier covering systems offered by manufacturers (a recent listing is available in "Compendium of Materials for Noise Control," Contract No. HSM 99-72-99, U.S. Department of Health, Education and Welfare, June 1975 (for sale by Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402). Some of these are listed below:

Roof or Wall Sound Barrier Systems:

Inland Ryerson Construction Products Co.
Box 393
Milwaukee, WI 53201

U.S. Gypsum Co. — 312/321-4000
101 South Wacker Drive
Chicago, IL 60606

Peticcal — 715/239-6411
Cornell Corp.
Cornell, WI 54732

Johns Manville Structural Systems
P.O. Box 435 — 609/448-8700
Brickyard Road
Cranburg, NJ 08512

The transmission losses for sound barrier materials are usually given in octave bands. In order to obtain the transmission loss in dBA, the distribution of sound energy in the octave bands is required; forge hammer sound (2500 lb hammer) has the frequency spectra given in Table V.11 below:

TABLE V.11. Octave Band Sound Pressure Spectra from a 2500 lb Hammer Measured 23 Feet from the Hammer

Octave Band Center Frequency	Sound Pressure Level - dB
125	89
250	99
500	101
1000	104
2000	101

The above information would enable the manufacturer of the sound barrier material to determine the transmission loss of their product to 2500 lb hammer noise (this sound spectra can be used to approximate other hammer sources).

Neighborhood Noise Control through Sound Absorption

The typical forge shop contains many square feet of acoustically "hard" surfaces that reflect sound waves with little energy loss and the noise level in the shop is increased due to resonance; the increased level in the shop (L_i) results in a higher noise level in the neighborhood.

Theoretically, reductions in the sound level in the neighborhood could be made by attaching sound absorptive materials to the forge shop interior walls and other interior surfaces. However, the areas to be covered in order to obtain a substantial reduction, e.g., 6 dBA, are very large and the costs would be high. In addition, the absorptive materials are porous and unless covered with a protective layer of plastic, will tend to collect oil mist. This leads to a real fire hazard (two have been experienced in forge shops from absorptive treatments).

Hence, absorptive treatments of forge plant interiors for neighborhood noise control are not recommended. Note, however, that a more limited application of absorptive surfaces such as on roof ventilator reflecting surfaces and in silencers can be useful.

Formulation of a Neighborhood Noise Control Plan

Neighborhood noise control planning must begin with the acoustically weakest element which is usually one or several of the ventilation openings. The steps on the formulation of a noise control plan is best done through an illustration — that of the hypothetical forge plant referred to in previous sections. Figure V.9 gives the pertinent data needed to formulate noise control planning. The data in Figure V.9.5 and V.9.7 show the usual situation — that the ventilation openings must be considered first in noise control planning. They also allow estimations of the contributions of the individual ventilation openings. The measured noise levels in Figure V.9.7 are very useful. For example, the radiation from the lower east opening alone would give a noise level of about 76 dBA at point B because the resultant level of 70 dBA (radiation from the balance of the building elements) plus 76 dBA would give the resultant level of 77 dBA. Likewise the open east wall windows yield about 73 dBA, the lower south (or north) wall openings 70 dBA and the open south (or north) wall windows about 68 dBA. The maximum reduction that can be expected from controlling the radiation through openings is about 9 dBA.

The methods available for attenuating the sound from the openings are discussed below:

Method 1: Close all shop openings. Expected Reduction: 8 to 9 dBA

All air circulation would stop and within tens of minutes the forge shop would be excessively hot on summer days. Method is not possible unless a mechanical ventilation system capable of supplying all of the air is installed.

Method 2: Close the east wall openings and all of the windows (repair if necessary). Expected Reduction: 4 to 5 dBA

The air circulation via wind pressure may be somewhat hampered but the control appears feasible. It is inexpensive and affords an appreciable reduction.

The sound level at point A is now determined by radiation through the north and south wall openings (70 dBA each) plus the balance of the building (≃70 dBA) for a resultant level of 75. The next step must involve reducing the sound from the north and south wall openings. One approach would be to simply reduce the open area by a factor of 2 or 3 by partially closing the steel doors. However, with most of the ventilation supplied naturally with wind pressure, closing down these openings without making some other provision for increasing the air flow will not be satisfactory. At this point, no further significant reductions can be made unless the ventilation for the building is revised. For example, sound radiation from the north and south walls could not be reduced with silencers or free standing walls because they would interfere excessively with air circulation.

Method 3: Close the east wall openings and all of the windows (repair if necessary).

Add a roof gravity ventilator 8 ft wide over the length of the forge shop. Place 10 dBA insertion loss silencers in both the north and south wall openings (1200 ft^2 of silencer face area). The sound pressure level at point B can be estimated and is given in Table V.12. From Table V.12, the noise reduction at point B is predicted to be about 8 dBA over the existing plant and only 3 to 4 better than that for method 2. The reason can be seen in Table V.12. The contributions of building elements such as the windows (60 + 55.5 + 55.5 = 62.3), the 26 gauge steel wall coverings (65 + 59.3 + 59.3 = 66.9) and the roof covering (62.3) are now major factors in determining the sound level in the neighborhood and unless they are replaced with materials having higher transmission losses, no further reductions in the neighborhood noise level can be made.

TABLE V.12. Calculated Sound Pressure Level at Neighborhood Point B (Figure V.9.2) after Closing the East Wall Openings, All the Windows, and Adding an Open Roof Ventilator and 10 dBA Insertion Loss Silencers in the North and South Wall Openings.

PLANT PERIMETER NOISE/VENTILATION CALCULATIONS

Industrial Noise Control Research Project

PLANT Hypothetical Forge Plant - Figure V.9   DATE ______

WEATHER ______

I. In-Plant Noise Levels

(a) Hammer Number #6 Board Rating 3000# (b) Hammer Number ______ Rating ______

Predicted SPL at 7m Li= 111 Measured Li= 110 Predicted SPL at 7m Li= ______ Measured Li= ______

II. Building Structure

Nr	Element	Sn(area) ft²	Sn(area) m²	Distance to Neighborhood point, r_n feet	meters	Construction Material(s)	R_n'	$\Delta Lr_n = 10 \log(\frac{2\pi r_n^2}{S_n})$	ΔL_2	$L'r_n = L_i - R_n' - \Delta Lr_n - \Delta L_2 - 6$ dBA
1	EWO	384		200		20 gauge steel	18		0	57.8 dBA
~~2~~ / 3	~~EWW~~	~~600~~		~~300~~		~~glass~~	~~18~~		~~0~~	~~60.0~~
4	EWSt	1000		200		26 gauge steel	15		0	65.0
								EW RESULTANT		66.7 dBA
5	SWO	600		260		silencers	10		6	59.5
~~6~~	~~SWW~~	~~1620~~		~~260~~		~~glass~~	~~18~~		~~6~~	~~56.5~~
7	SWH									
8	SWst	1200		260		26 gauge steel	15		6	59.3
								SW RESULTANT		63.2
	NORTH WALL IS IDENTICAL TO SOUTH WALL							NW RESULTANT		63.2
9	RSH	(2800-1100)		250		steel, tar, gravel	20		5	[illegible]
10	RWH	(2800-1100)		250		" " "	20		5	[illegible]
11	RV	28		250		open	0		5	[illegible]
11'	Gravity Ventilator	1100		250		plenum	10		5	63.5
								ROOF RESULTANT		65.3
								OVERALL		71 dBA

* West wall neglected here, the contribution is small.

3

Method 4:

1. Close the east and west wall openings and all of the windows (repair if necessary).
2. Add a roof gravity ventilator 8 ft wide over the length of the forge shop. The interior surfaces have absorptive material.
3. Place 20 dBA insertion loss silencers in both the north and south wall openings.
4. Replace the east, south and north wall 26 gauge steel with 3/8" asbestos (25 dBA transmission loss), a total of 4600 square feet.

The sound pressure level at point B can again be calculated as shown in Table V.13.

On comparing the resultant overall level in Table V.13 with the very extensive changes made, one can realize the difficulties on effective control of neighborhood noise near hammer forge shops. Any further reduction would obviously require changes in almost every building element on the east, south and north walls of the building. The windows would have to be replaced, the roof redone, silencers would have to be applied to the roof ventilator, the roof propellor fans replaced with vaneaxial fans with silencers on the exhaust side. Even then, it is doubtful whether the regulation level of 56 dBA could be reached. In order to do that, each of the 13 elements would have to be changed to bring their individual contributions to about 44 dBA!

Estimated Costs of Neighborhood Noise Control

Unfortunately, there is no actual experience on which to base the costs for reductions in neighborhood noise levels.

Bolt, Beranek and Newman have estimated the costs for specific Illinois forge plants that reflect improvements with regard to adjoining Class A

TABLE V.13. Calculated Sound Pressure Level at Neighborhood Point B After the Changes in Method 4 Are Completed.

PLANT PERIMETER NOISE/VENTILATION CALCULATIONS

Industrial Noise Control Research Project

PLANT Hypothetical Forge Plant - Figure V.9

DATE ______

WEATHER ______

I. In-Plant Noise Levels

(a) Hammer Number [illegible] Rating 3000# Measured Li= 110
Predicted SPL at 7m Li= [illegible]

(b) Hammer Number ______ Rating ______
Predicted SPL at 7m Li= ______ Measured Li= ______

II. Building Structure

Nr	Element	Sn(area) ft²	Sn(area) m²	Distance to Neighborhood point, r_n feet	meters	Construction Material(s)	R'_n	$\Delta Lr_n = 10 \log(\frac{2\pi r_n^2}{Sn})$	ΔL_z	$L'r_n = L_i - R'_n - \Delta Lr_n - \Delta L_z$ dBA
						10 gauge steel	18		0	57.8
1	EWO	384		200		glass	13		0	60
2,3	EWH	600		300		3/8" asbestos	25		0	53
4	EW(?)	1000		300				EW RESULTANT		62.8
									6	54.5
						silencers	15			
5	SWO	600		250		glass	13		6	55.5
6,7	SWH	1550		250		3/8" asbestos	25		6	49.3
8	SW(?)	1500		250				SW RESULTANT		58.6
								"		58.6
	North Wall is identical to South Wall									
						steel, fan, ground	20			50.5
9	RSH	(2300-1100)		250		" " "	20			50.5
10	RNH	(2300-1100)		250		open	0			50.5
11	RV	22		250		silencer	14			59.5
11'	Gravity Ventilator	1100		250		with absorptive material		ROOF RESULTANT		63.1
								OVERALL		67.9 dBA

Closed [illegible] wall contribution can be neglected (residential lands). The cost estimates contained in the report were averaged for the various noise reduction ranges and are reported in Table V.14 in terms of dollars/sq.ft. of shop elevation involved in the improvements (for example, in the hypothetical forge plant of Figure V.9 the east, north and south elevations were modified as discussed in Table V.12; the total building elevation area involved was 9800 ft^2).

TABLE V.14. Estimates* of Neighborhood Noise Reduction Costs per Square Foot of Revised Shop Elevation

Noise Reduction	5 dBA	10 dBA	15 dBA	20 dBA	25 dBA
Average Cost per ft^2	$16.00	$20.00	$23.00	$34.00	$40.00
Highest Cost per ft^2	21.00	27.00	30.00	48.00	57.00
Lowest Cost per ft^2	10.00	14.00	19.00	28.00	33.00

* 1976-77 prices

EXHIBIT #2

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V. ENGINEERING GUIDELINES: NEIGHBORHOOD NOISE CONTROL

A. PROBLEM STATEMENT

The major sources of neighborhood noises from forge plants with their control possibilities are given below:

Source: Impact forging operations

The loud and distinctive impulse sounds from impact forging constitute by far the single most important neighborhood noise problem for the forging industry.

Control Methods: Acoustical strengthening of the forge plant structure as a sound barrier. There is no technically feasible method for control at the source and practical, acoustically effective hammer enclosures have not been demonstrated.

Source: Roof steam exhausts

This source results in continuous, broad band sound from roof locations that usually have unobstructed paths to receiving property.

Control Methods: This source can be controlled (see Section IV.G, IV.13).

Sources: Shearing and stock handling

Impulse noises from these processes can give rise to neighborhood problems if the operations are carried out near building openings or outdoors.

Control Methods: Source control (see IV.E, page IV.11) or source enclosure.

Source: Man coolers and furnaces

These noise sources emit continuous sounds particularly noticeable at night when the balance of the plant is inoperative.

Control Methods: Source control (see IV.F, page IV.2 and IV.A, page IV.6) or strengthening of the forge plant as an acoustical barrier.

Sources: Warning bells, buzzers and horns

Control Methods: Reduce loudness or relocate source; reduce sound transmission from building.

The control of neighborhood noise can generally be separated with the following tasks:

1. Determination of the existence of neighborhood noise problems through a noise survey and a comparison of the measured levels with the applicable regulations.
2. Identification of the plant noise source(s) giving violations.
3. Formulation of a Noise Control Plan.
4. Implementation and concurrent evaluation of the Plan.

In some cases it may be advisable (or even required) to have the Noise Control Plan evaluated by the appropriate regulatory agency prior to proceeding with implementation of the Plan.

B. NEIGHBORHOOD NOISE SURVEYS

Instrumentation

The selection of a sound level meter depends on the nature of the emitted sound and on the specification of the noise limits:

Nature of the Sound	Allowable Noise Level Specified as	Meter Selection
Continuous	A-weighted limit	Type 2 (or Type 1)
Continuous	Octave band limit	Type 1
Impulsive	A-weighted limit	Type 2 (or Type 1)
Impulsive	True peak limit	Type 1

Measurements:

1. Measure the neighborhood noise levels on the side of the "worst" condition

   - the noisiest equipment (e.g., the largest hammers) are operating

   - The temperature is in the range of 75° to 85°F and the ventilation openings are fully opened

   - there are low wind velocities (less than 10 mph) towards the measurement point from the source.

2. Calibrate; attach the wind screen; set meter to scales, responses required in applicable regulations

3. Make measurements at the nearest receiving land property lines; avoid if possible locations that are not in line-of-sight of the forge plant or those near reflecting surfaces of buildings, etc.

4. Keep careful records (see Volume II, Page V.5) that include noise source identification

C. NEIGHBORHOOD NOISE CONTROL FOR EXISTING PLANTS

This section considers control of neighborhood noise through increasing the acoustical strength of the plant building structure. The methods are directed towards hammer impulse noise control in the neighborhood but can be applied to other in-plant noise sources giving neighborhood noise problems.

Preliminary Assessment

A preliminary assessment of a forge plant's impulsive noise situation can be made with the aid of Table V.1. (page V.4)

Example: you operate a forge plant with 4000 lb. gravity hammers. The nearest residential receiver line is 400 feet away; the allowable sound level at the receiver line is 56 dBA.

1. What is approximate noise level at the residential receiver line? About 75 dBA (72+3 added for U.S. plants).

Hammer Rating - lbs.

Values in each cell: (a) / (b) / (c)

Power Hammer	Gravity Hammer	50	100	200	300	400	500	600	800	1000		2000	3000
4500	10000	(a) 95 dBA$_f$ / (b) 89 / (c) 76	89 - Existing Plants / 83 - Revised Plants / 70 - New Plants	83 / 77 / 64	80 / 74 / 61	77 / 71 / 58	75 / 69 / 50	74 / 68 / 55	71 / 65 / 52	69 / 63 / 50	66 / 60 / 47	63 / 57 / 44	60 / 54 / 41
3500	8000	(a) 93 / (b) 87 / (c) 74	87 / 81 / 68	81 / 75 / 62	78 / 72 / 59	75 / 69 / 56	73 / 67 / 54	72 / 66 / 53	69 / 63 / 50	67 / 61 / 48	64 / 58 / 45	61 / 55 / 42	58 / 52 / 39
2500	6000	(a) 92 / (b) 86 / (c) 73	86 / 80 / 67	80 / 74 / 61	77 / 71 / 58	74 / 65 / 55	72 / 66 / 53	71 / 65 / 52	68 / 62 / 49	66 / 60 / 47	63 / 57 / 44	60 / 54 / 41	57 / 51 / 38
	5000	(a) 91 / (b) 85 / (c) 72	85 / 79 / 66	79 / 73 / 60	76 / 70 / 51	73 / 67 / 54	71 / 65 / 52	70 / 64 / 51	67 / 61 / 48	65 / 59 / 46	61 / 56 / 43	59 / 53 / 40	56 / 50 / 37
	4000	(a) 90 / (b) 84 / (c) 71	84 / 78 / 65	78 / 72 / 59	75 / 69 / 56	72 / 66 / 53	70 / 64 / 51	69 / 63 / 50	66 / 60 / 47	64 / 58 / 45	61 / 55 / 42	58 / 52 / 39	55 / 49 / 36
	3000	(a) 89 / (b) 83 / (c) 70	83 / 77 / 64	77 / 71 / 58	74 / 68 / 55	71 / 65 / 52	69 / 63 / 50	68 / 62 / 49	65 / 59 / 46	63 / 57 / 44	60 / 54 / 41	57 / 51 / 38	54 / 48 / 35
	2000	(a) 88 / (b) 82 / (c) 69	82 / 76 / 63	76 / 70 / 57	73 / 67 / 54	70 / 64 / 41	68 / 62 / 49	67 / 61 / 48	64 / 58 / 45	62 / 56 / 43	59 / 53 / 40	56 / 50 / 37	53 / 47 / 34
	1000	(a) 87 / (b) 81 / (c) 68	81 / 75 / 62	75 / 69 / 56	72 / 66 / 53	69 / 63 / 50	67 / 61 / 48	66 / 60 / 47	63 / 57 / 44	61 / 55 / 42	58 / 52 / 39	55 / 49 / 36	52 / 46 / 33

Distance from Neighborhood Point to Wall in Feet

TABLE V.1. Noise Level, dBA$_f$, Peak vs. Hammer Size and Distance (VDI 2561)(add 3 dBA for U.S. Plants) for (a) Existing Plants with No Noise Control, (b) Existing Plants with Noise Control Revisions and (c) New Plants Specifically Designed for Noise Control. (Note: for dBA Slow Meter Response, the Sound Levels Will Be 2-3 dBA Lower.)

2. Is it likely that your plant can meet the regulatory value with feasible revision? No! Table V.1 predicts a level of 69 dBA (66+3) for revised U.S. forge plants.

3. If you built a new forge plant specifically designed for neighborhood noise control on the same site, would the regulation be met? Probably. Table V.1 predicts a level of about 56 (53+3) dBA.

See Volume II, pages V.8,9 for an extension of this method for large steam hammers and other in-plant noise sources.

Detailed Calculations of Sound Emission from Forge Plants

It is possible to make predictions of the neighborhood noise levels for a forge plant on a more detailed basis. The general idea of the method (after VDI 2571, reference 2, Volume II) is that impact forging creates impulsive sound within the plant; some of this sound is radiated from the plant through building elements (openings, walls, roofs, etc.) to neighborhood points. The sound radiated through each building element can be calculated given its area, sound transmission loss (ability to act as a sound barrier), the shielding of the element and distance to the neighborhood point. The method is important because it identifies the building elements that must be treated in order to reduce neighborhood levels, and can predict the reduction obtainable. (See Volume II, page V.13 to V.19 for an explanation of the method and a sample calculation).

Forge Plant Ventilation

Sound radiation through ventilation openings almost always determine the neighborhood noise levels near forge plants. Therefore, the ventilation requirements for a forge plant must always be considered before a noise control plan can be drafted.

The ventilation needs (CFM of outside air) of forge plants can be calculated given the fuel consumption of stock heating furnaces (Volume II, pages V.20-21)

The wall (air intake) and roof (air exhaust) opening areas for natural draft ventilation can also be calculated (Volume II, pages V.22 to V.26)

It should be noted that almost all U.S. forge plants rely mainly on natural ventilation, and that a forge plant successfully ventilated by mechanical means has not been demonstrated.

Neighborhood Noise Control Planning for Existing Plants: Necessary Preliminary Tasks

Ideally, the objective of neighborhood noise control planning would be to determine the most cost effective methods of reducing sound levels to regulatory values. Unfortunately, compliance cannot be achieved for most existing forge plants through feasible control methods. The objective of noise control planning then becomes less clear - one of attempting to determine what can be done through a reasonable effort. The decision as to what is reasonable will probably be made by the regulatory agency or the board overseeing the administration of the regulations. This guideline makes no attempt to determine what changes are reasonable but does show what changes might be made, indicates the cost of the changes, and estimates the effect of the changes on the neighborhood sound levels.

Neighborhood Noise Control First Requires The Assembling of The Following Information:

1. a copy of the neighborhood noise rules and regulations that apply.
2. a neighborhood noise survey which gives the sound levels at receiving lands measured in accordance with the applicable regulations.

3. a scale site layout for your forge plant showing the location of the forge shop (and other noise sources) giving rise to neighborhood noise problems. The receiving lands should be classified and the regulatory levels for each land classification given.

4. Forge shop elevations and hammer shop floor plan. The elevations should describe the building elements (areas, covering materials). The floor plan locates problem noise sources and gives, L_i, the in-plant sound pressure level from each source.

It is also important that you create "standards" through which changes in the sound level can be determined accurately:

a. Select a limited number of neighborhood test points in most serious problem areas for use in calculations and as measurement points to monitor changes in the neighborhood sound levels with changes in the plant structure.

b. Identify the hammer(s) giving the highest impulse sound levels at the test points and select a forging that you make often as the "test" forging; the finishing blows will then create a standard in-plant sound level.

c. Define a standard condition for the plant structure which is normal for summer operation, i.e., the ventilation openings are set as usual for the hot days.

(See Volume II, Figure V.9.1, to V.9.4, pages V.29 and V.30 for a sample compilation of (1), (2), (3), (4), and (a), (b), and (c) above)

The following steps in formulating the neighborhood noise control plan can now be done:

1. Detailed calculation of the contribution of the plant building elements to the noise levels in the neighborhood.
2. Calculation of the ventilation requirements.
3. Measurement of the neighborhood sound pressure levels with the forge plant ventilation openings both closed and open.

(See Volume II, Figures V.9.5, V.9.6 and V.9.7 for examples)

Neighborhood Noise Control Plan Formulation

From the proceeding you should have obtained understanding of your neighborhood noise situation, e.g., a rough idea of the noise reduction you may be able to attain and which of the building elements "contribute" most to the neighborho d levels.

Noise reduction planning must begin with noise control treatments at the acoustically "weakest" elements, which are usually the ventilation openings. The controls available are (see Volume II, Page V.32):

1. Reduce the opening sizes (3dBA reduction per area halving) if permitted by ventilation requirements
2. Shield the lower wall openings with a free standing wall
3. Apply duct silencers to the openings
4. Place a gravity ventilator in roof opening.

Calculations will probably show that after one or more of the above controls is applied, radiation through other building elements becomes significant (see Volume II, page V.42 - method 3) and that further neighborhood noise reduction requires replacing wall and roof elements with acoustically "stronger" barrier materials, e.g. 26 gauge steel roofing with an acoustical roof deck. (see Volume II, pages V.37 through V.40). At this point it should be clear why neighborhood noise control for forge plants is so difficult and why the feasible reductions are usually limited to 5 to 10dBA (recall Table V.1). Really effective noise control (10 to 20dBA sound level reductions needed in many cases for compliance) requires plant reconstruction.

Theoretically, reductions in the sound level in the neighborhood could be made by attaching sound absorptive materials to the forge shop interior walls and other interior surfaces. However, the areas to be covered in order to obtain a substantial reduction, e.g., 6 dBA, are very large and the costs would be high. In addition, the absorptive materials are porous and unless covered with a protective layer of plastic, will tend to collect oil mist. This leads to a real fire hazard (two have been experienced in forge shops from absorptive treatments).

Hence, absorptive treatments of forge plant interiors for neighborhood noise control are not recommended. Note, however, that a more limited application of absorptive surfaces such as on roof ventilator reflecting surfaces and in silencers can be useful.

Estimated Costs of Neighborhood Noise Control

Unfortunately, there is no actual experience on which to base the costs for reductions in neighborhood noise levels.

For Specific Illinois Forge Plants

Bolt, Beranek and Newman have estimated the costs that reflect improvements with regard to adjoining Class A (residential) lands. The cost estimates contained in the report were averaged for the various noise reduction ranges and are reported in Table V.2 in terms of dollars/sq.ft. of shop elevation involved in the improvements.

TABLE V.2 Estimates of Neighborhood Noise Reduction Costs per Square Foot of Revised Shop Elevation

Noise Reduction	5 dBA	10 dBA	15 dBA	20 dBA	25 dBA
Average Cost per ft^2	$16.00	$20.00	$23.00	$34.00	$40.00
Highest Cost per ft^2	21.00	27.00	30.00	48.00	57.00
Lowest Cost per ft^2	10.00	14.00	19.00	28.00	33.00

D. NOISE CONTROL AND SITE SELECTION FOR NEW PLANTS

The outlook for effective noise control in the building of a new forging plant is much brighter. Although the size of impact forging equipment will be fixed by manufacturing needs, the builder has the options of plant type and plant site selections.

The most cost-effective selection must clearly consider the relative costs of the plant construction and plant site; plants constructed incorporating effective noise control will be more expensive but the land area required for compliance with noise regulations will be reduced. An example of estimating the site requirements for a hypothetical forge shop with 3 types of construction (3 differing acoustical barrier strengths) is given in Volume II, page V.48.

VI. FORGE HAMMER IMPACT NOISE

To the date of this guideline (March 1977), there is no feasible method of controlling impulse noise emission from forge hammers at the source, nor is there one within sight.

Research directed towards hammer impact noise control continues in the United States, West Germany, Sweden and the United Kingdom. Chapter VI of Volume II describes the results of these efforts and discusses some of the prospects for control in the future.

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34.6. - 7

EXHIBIT #3

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION
R 1996

ACOUSTICS

ASSESSMENT OF NOISE
WITH RESPECT TO COMMUNITY RESPONSE

1st EDITION

May 1971

For each individual country the only valid standard is the national standard of that country.

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3

Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 1996, *Acoustics – Assessment of noise with respect to community response*, was drawn up by Technical Committee ISO/TC 43, *Acoustics*, the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question led to the adoption of Draft ISO Recommendation No. 1996, which was circulated to all the ISO Member Bodies for enquiry in May 1970. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	France	New Zealand
Austria	Germany	Norway
Belgium	Greece	South Africa, Rep. of
Canada	Hungary	Sweden
Czechoslovakia	Ireland	Switzerland
Denmark	Japan	U.A.R.
Finland	Netherlands	U.S.S.R.

The following Member Bodies opposed the approval of the Draft :

United Kingdom
U.S.A.

This Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided to accept it as an ISO RECOMMENDATION.

ACOUSTICS

ASSESSMENT OF NOISE

WITH RESPECT TO COMMUNITY RESPONSE

INTRODUCTION

The reduction, or limitation, of noise which causes annoyance is of increasing general importance. This ISO Recommendation suggests methods for measuring and rating noises in residential, industrial and traffic areas with respect to their interference with rest, working efficiency, social activities and tranquillity.

Besides noise there may be other factors in connection with sound production and radiation, for example mechanical vibrations, which also give rise to annoyance in particular situations and which make the assessment more complex. No general method exists at present to take account of these factors, but the application of numbers and corrections, other than those described, may be desirable in some cases.

The method described in this ISO Recommendation is considered suitable for predicting approximately the public reaction likely to be caused by noise, and may help authorities to set limits for noise levels.

Some problems related to aircraft noise are treated separately; see ISO Recommendation R 507*, *Procedure for describing aircraft noise around an airport.*

1. SCOPE

This ISO Recommendation is intended as a guide to the measurement of the acceptability of noise in communities. It specifies a method for the measurement of noise, the application of corrections to the measured levels (according to duration, spectrum character and peak factor), and a comparison of the corrected levels with a noise criterion which takes account of various environmental factors.

The method given for rating noises with respect to community response forms a basis on which limits for noises in various situations may be set by the competent authorities.

The method of rating involves the measurement of the A-weighted sound level in decibels (commonly called dB(A))**.

Where corrective measures are required, a frequency analysis may be necessary. The resulting data may be compared with noise rating curves, for instance the NR-curves, in order to identify the intrusive frequency bands. This more elaborate procedure is described in Appendix Y.

* 2nd edition, 1970.

** As defined in IEC Publication 123, *Recommendations for sound level meters*, or IEC Publication 179, *Precision sound level meters.*

2. NOISE MEASUREMENT

2.1 Measuring equipment

The measurements should be made with a sound level meter as specified in IEC Publication 123, *Recommendations for sound level meters*, or IEC Publication 179, *Precision sound level meters*. The A-weighting network and fast response should be used. The sound level should be measured at the place and time of the annoyance.

NOTE – Other measuring equipment including, for example, a level recorder or tape recorder, may be used if the overall performance conforms with the characteristics of a sound level meter with A-weighting network and with fast response.

2.2 Measurement conditions

2.2.1 Outdoor measurements should be made at 1.2 to 1.5 m above the ground and, if practical, at least 3.5 m from walls, buildings or other sound reflecting structures. When circumstances indicate, measurements may be made at greater heights and closer to the wall (for example 0.5 m in front of an open window), provided this is specified and taken into consideration.

NOTES

1. Care should be taken to avoid influence on the result from unwanted sound signals, for example noise from wind on the microphone of the measuring equipment, noise from electrical interference or noise from extraneous sources.
2. When the noise source is distant, the measured sound level may depend significantly on the climatic conditions. It is recommended that extreme conditions be avoided. If possible, a typical value and an indication of the range of variation should be obtained.

2.2.2 Indoor measurements should be made at a distance of at least 1 m from the walls, 1.2 to 1.5 m above the floor, and about 1.5 m from the window(s). In order to reduce disturbances from standing waves, the sound levels measured indoors should be averaged over ± 0.5 m about each of at least three positions. This is especially important when measuring low-frequency noise. The arithmetic average of the readings determines the value to be taken.

The measurements should generally be made with windows closed. If the room is regularly used with open windows, measurements should also be made under this condition.

If the noise is not steady, the level and duration of the noise must be determined; if necessary, records of the level may be made. The period of time in which the time history of the sound level is observed must be chosen according to the character of the variations of the noise. If possible, the period should cover more than one typical variation cycle.

3. DETERMINATION OF THE RATING SOUND LEVEL L_r

In many cases corrections to the measured sound level, L_A, are needed to obtain a better estimate of the community response to the noise. These corrections are dependent on the character of the noise with respect to peak factor, spectrum character, duration and fluctuation. The sum of L_A and possible corrections is termed the rating sound level, L_r, i.e. the sound level of a steady noise without impulsive character or pure tones which is assumed to cause the same community response as the measured noise.

3.1 The procedure is as follows :

3.1.1 Steady noise (such as rain noise) without impulsive character or audible tones is rated by the sound level L_A in dB(A), measured by means of the sound level meter.

3.1.2 Steady noise with an impulsive character (such as hammering or riveting) or with discrete noise impulses is rated by the sound level L_A in dB(A) plus the correction given in Table 1, first entry.

The reading to be taken is the average of the maximum deflections of the pointer.

NOTES

1. Other techniques for measuring and rating impulsive noise may become appropriate, especially when recommendations for suitable measuring instruments are published.
2. If the sound level varies over a large range, the procedure described in clause 3.1.5 should be used.

3.1.3 Steady noise which contains audible tone components (for example whine, screech or hum) is rated by the sound level L_A in dB(A) plus the correction given in Table 1, second entry.

3.1.4 If the noise is interrupted by pauses (for example almost unchanging factory noise lasting for several hours followed by a pause), a correction according to Table 1, third entry, should be applied to the sound level L_A to take account of the reduced duration of the noise.

The duration of the noise should be reckoned over a relevant time period which may be set according to the specifications by local authorities, for example the most unfavourable eight consecutive hours during daytime, and the most unfavourable half-hour of the evening or the night. For noise during the night it may be advantageous also to set an absolute limit for the sound level.

NOTES

1. The time limits for "day", "evening", and "night" may vary in different countries and may be defined by local authorities according to the way in which the ambient traffic noise varies and according to the habits of people. (For instance in some areas "day" lasts from 06.00 until 18.00, "evening" from 18.00 until midnight, and "night" from midnight until 06.00).
2. By specifying a shorter period or an absolute limit during evening and night, the influence of noises with high levels and short duration is emphasized. Such noise may be disturbing for sleep.
3. If a particular noise source is to be considered at weekends, measurements must take into account the circumstances of the weekend, for example by measuring the background noise at the relevant time.

3.1.5 If the noise varies with time in a more complicated manner than is appropriate for the use of Table 1, the equivalent sound level L_{eq} should be obtained, for example from a statistical analysis of the time history of the A-weighted sound level. The corrections in Table 1 for peak factor or noise spectrum character should also be applied when appropriate.

The statistical analysis can be based on analogue or digital recordings of the sound level. For estimating purposes it may in some cases be sufficient to determine the statistical distribution by observing the sound level meter readings at intervals of time by a sampling technique.

The class intervals for the sound level must be chosen according to the character of the noise; in most cases an interval of 5 dB will be appropriate.

The equivalent sound level L_{eq} is calculated from a formula based on the equal energy principle :

$$L_{eq} = 10 \log_{10} \left[\frac{1}{100} \sum f_i 10^{L_i/10} \right]$$

where

L_{eq} is the equivalent sound level in dB(A);

L_i is the sound level in dB(A) corresponding to the class-midpoint of the class i (for class intervals not greater than 5 dB(A) the arithmetic means can be used; for larger intervals logarithmic averaging should be used);

f_i is that time-interval (expressed as a percentage of the relevant time period) for which the sound level is within the limits of class i.

The relevant time period should be chosen according to the specifications of the local authorities (see clause 3.1.4).

TABLE 1 – Corrections to the measured sound level in dB(A)

Characteristic features of the noise		Correction dB(A)
Peak factor	Impulsive noise (e.g. from hammering)	+ 5
Spectrum character	Audible tone components present (e.g. whine)	+ 5
Duration of the noise with sound level L_A as a percentage of the relevant time period	Between : 100 and 56 56 and 18 18 and 6 6 and 1.8 1.8 and 0.6 0.6 and 0.2 Less than 0.2	 0 – 5 – 10 – 15 – 20 – 25 – 30

3.2 Hence, the rating sound level is determined as follows :

– for noises of constant level, by

$L_r = L_A + 5$ when the noise is impulsive or when it contains audible tone components or both

+ correction for duration when the noise is intermittent;

– for noises of fluctuating level, by

$L_r = L_{eq} + 5$ when the noise is impulsive or when it contains audible tone components or both.

4. NOISE CRITERIA

In general, a noise is liable to provoke complaints whenever its level exceeds by a certain margin that of the pre-existing background noise, or when it attains a certain absolute level.

The method of rating noise is based on a comparison of the rating sound level with a criterion level which takes various features of the environment into account. The criterion is related to the pre-existing background level, either fixed for a certain zone in general or directly measured for special cases.

The method for deriving a criterion for rating noise in general (for example for zoning purposes) is given in clause 4.1; the method for rating noise in special cases, based on the measured background level, is given in clause 4.2 In section 5 a rough connection between public reaction and noise exceeding the criterion is given.

4.1 Noise criteria in general

Noise criteria in general, especially for the purpose of zoning, can be derived from one basic value by adding corrections for time of day and corrections for the different types of district.

The basic value for a country has to be established according to the living habits of the people.

NOTE. – The basic criterion for residential premises should usually be in the range of 35 to 45 dB(A) for outdoor noise.

4.1.1 The corrections to the basic criterion for different times of day are given in Table 2.

TABLE 2 – Corrections to basic criterion for different times of day

Time of day	Correction to basic criterion dB(A)
Day time	0
Evening	−5
Night time	−10 to −15

It may be appropriate to use only day time and night time with the corrections given above, and to omit evening.

4.1.2 The corrections to the basic noise criterion for residential premises for different zones are given in Table 3.

Local experience in different countries will lead to different definitions of the relevant types of zones, taking into account existing laws or prescriptions.

TABLE 3 – Corrections to basic criterion for residential premises in different zones

Type of district	Correction to basic criterion dB(A)
Rural residential, zones of hospitals, recreation	0
Suburban residential, little road traffic	+ 5
Urban residential	+ 10
Urban residential with some workshops or with business or with main roads	+ 15
City (business, trade, administration)	+ 20
Predominantly industrial area (heavy industry)	+ 25

4.2 Special cases

For rating noise in special cases, for example in case of complaints of a certain noise source at a certain place, the background noise level serves as the criterion.

The background (ambient) noise level is the mean minimum sound level at the relevant place and time in the absence of the noise which is alleged to be offending. It should be obtained by observing the pointer of the sound level meter and by reading the lowest level which is repeated several times (mean minimum). When statistical analysis of the sound level is used, the background noise level should be taken as that level which is exceeded for 95 % of the observation time.

NOTES

1. The background noise level includes appropriately the influences of the type of district, the season and the time of day, and no correction has to be used. It serves in the same way for assessment of noise outside or inside a building, with windows open or closed, provided it is measured under the same conditions as the noise.

2. To prevent a creeping (gradually increasing) background noise level, it may be useful to compare the measured background level with the general criterion derived according to clause 4.1 for the relevant district and time.

5. ASSESSMENT OF THE NOISE WITH RESPECT TO COMMUNITY RESPONSE

In order to assess the noise with respect to the expected community response, the rating sound level as obtained according to section 3 should be compared with the criterion value given in clause 4.1 or clause 4.2.

If the rating sound level exceeds the criterion value, the noise is likely to evoke response from the community. Differences of 5 dB(A) or less are of marginal significance; complaints may certainly be expected if the difference reaches 10 dB(A) or more. An estimate of the public reaction which may be obtained where the rating sound level exceeds the criterion value by a certain amount is given in Table 4.

TABLE 4 – Estimated community response to noise

Amount in dB(A) by which the rating sound level L_r exceeds the noise criterion	Estimated community response	
	Category	Description
0	None	No observed reaction
5	Little	Sporadic complaints
10	Medium	Widespread complaints
15	Strong	Threats of community action
20	Very strong	Vigorous community action

6. STATEMENTS IN THE REPORT

The report should state :

(a) the measured sound level L_A in dB(A);

(b) the duration of the noise or, for varying levels, the statistical distribution;

(c) operating conditions of the noise source and weather conditions (where applicable);

(d) the time of day on which the noise occurs and the measurements have been made;

(e) the corrections applied to L_A;

(f) the rating sound level L_r;

(g) the measured background noise level (where applicable);

(h) the noise criterion value derived for the relevant time and district (where applicable).

APPENDIX Y

FREQUENCY ANALYSIS

The recommended method of rating, based on measurements of the A-weighted sound level, is given in the body of this ISO Recommendation. However, a frequency analysis of the noise will in some cases be valuable for rating purposes and is essential if corrective measures to reduce the noise nuisance are to be evaluated. In this case a set of noise rating curves, with which the measured spectrum of the noise can be compared, can be employed. This makes an identification of the intrusive frequency bands possible. There are a number of sets of such curves, one of which is the NR-curves.

The NR-curves are given in the following Figure and the octave band pressure levels corresponding to the curves are tabulated in Table 5.
An octave band analysis of the noise in the range 31.5 to 8000 Hz (centre-frequencies) should be made with filters according to IEC publication 225, *Octave, half-octave and third-octave band filters intended for the analysis of sound and vibrations.* These octave band pressure levels should be corrected, if necessary, according to section 3. To each corrected band pressure level an NR-number, in accordance with Table 5 or the Figure, should be assigned. These numbers can be compared with a criterion in NR-numbers, the numerical value of which may be taken as 5 lower than the criterion according to section 5 in dB(A).

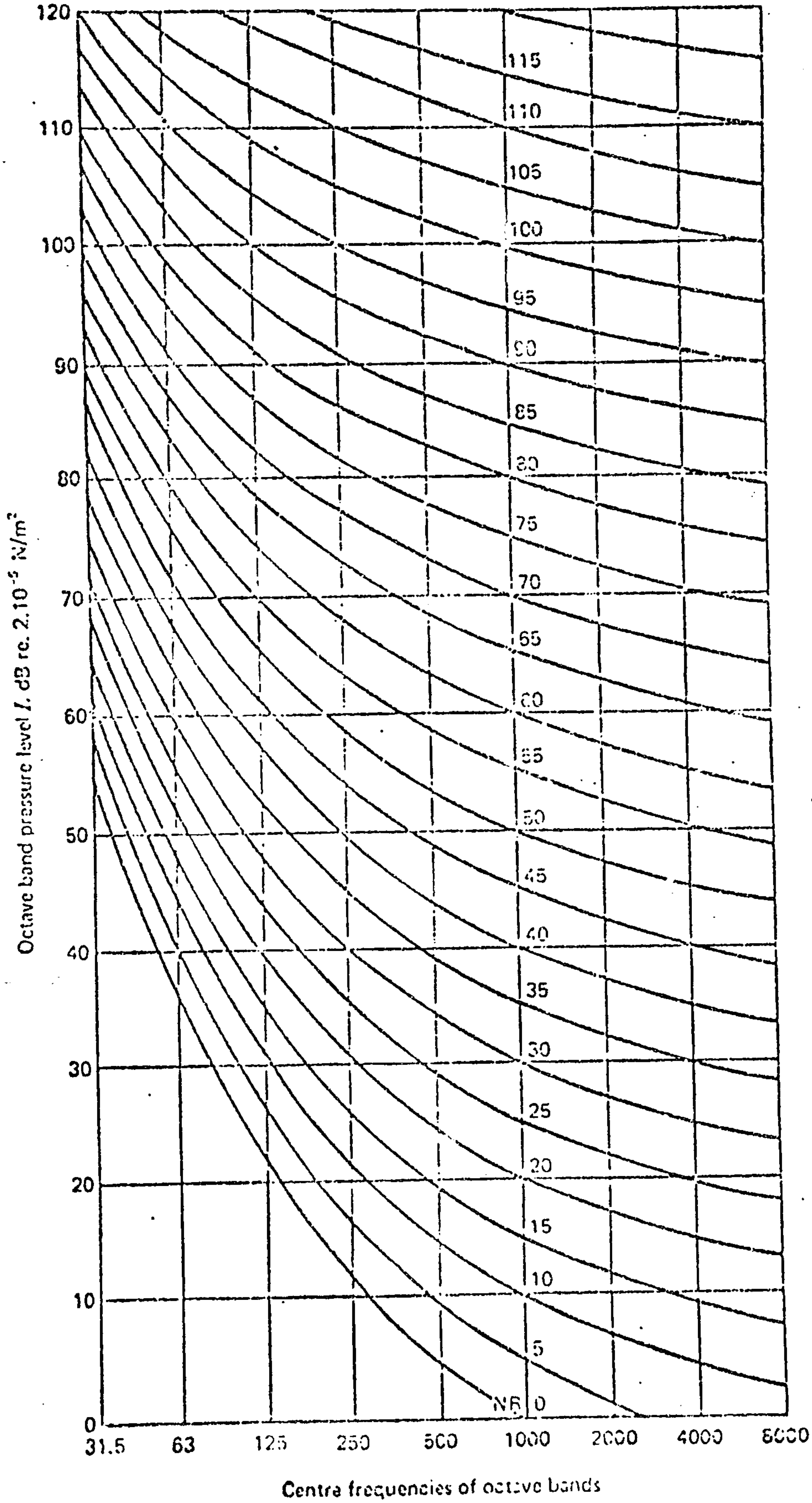

FIGURE - Noise rating curves

TABLE 5 – Octave band pressure levels corresponding to noise rating number NR

NR	Octave band sound pressure levels (dB)								
	Centre frequencies (Hz)								
	31.5	63	125	250	500	1000	2000	4000	8000
0	55.4	35.5	22.0	12.0	4.8	0	−3.5	−6.1	−8.0
5	58.8	39.4	26.3	16.6	9.7	5	+1.6	−1.0	−2.8
10	62.2	43.4	30.7	21.3	14.5	10	6.6	+4.2	+2.3
15	65.6	47.3	35.0	25.9	19.4	15	11.7	9.3	7.4
20	69.0	51.3	39.4	30.6	24.3	20	16.8	14.4	12.6
25	72.4	55.2	43.7	35.2	29.2	25	21.9	19.5	17.7
30	75.8	59.2	48.1	39.9	34.0	30	26.9	24.7	22.9
35	79.2	63.1	52.4	44.5	38.9	35	32.0	29.8	28.0
40	82.6	67.1	56.8	49.2	43.8	40	37.1	34.9	33.2
45	86.0	71.0	61.1	53.6	48.6	45	42.2	40.0	38.3
50	89.4	75.0	65.5	58.5	53.5	50	47.2	45.2	43.5
55	92.9	78.9	69.8	63.1	58.4	55	52.3	50.3	48.6
60	96.3	82.9	74.2	67.8	63.2	60	57.4	55.4	53.8
65	99.7	86.8	78.5	72.4	68.1	65	62.5	60.5	58.9
70	103.1	90.8	82.9	77.1	73.0	70	67.5	65.7	64.1
75	106.5	94.7	87.2	81.7	77.9	75	72.6	70.8	69.2
80	109.9	98.7	91.6	86.4	82.7	80	77.7	75.9	74.4
85	113.3	102.6	95.9	91.0	87.6	85	82.8	81.0	79.5
90	116.7	106.6	100.3	95.7	92.5	90	87.8	86.2	84.7
95	120.1	110.5	104.6	100.3	97.3	95	92.9	91.3	89.8
100	123.5	114.5	109.0	105.0	102.2	100	98.0	96.4	95.0
105	126.9	118.4	113.3	109.6	107.1	105	103.1	101.5	100.1
110	130.3	122.4	117.7	114.3	111.9	110	108.1	106.7	105.3
115	133.7	126.3	122.0	118.9	116.8	115	113.2	111.8	110.4
120	137.1	130.3	126.4	123.6	121.7	120	118.3	116.9	115.6
125	140.5	134.2	130.7	128.2	126.6	125	123.4	122.0	120.7
130	143.9	138.2	135.1	132.9	131.4	130	128.4	127.2	125.9

APPENDIX Z

RATING INDOOR NOISE

General criterion values for rating noise inside residential premises can be derived from those for outdoor noise, specified in clause 4.1, by adding corrections according to the decrease in sound level from outdoors to indoors with open and closed windows.

These corrections are given in Table 6.

TABLE 6 – Corrections to the general noise criterion for outdoor noise to derive general noise criterion for indoor noise

Window conditions	Correction dB(A)
Windows open	−10
Single windows shut	−15
Double windows shut or non-openable windows	−20

Usually, the noise criterion should not be set below 20 dB(A).

NOTE. – The corrections are approximations and may vary with the area and the sound insulation of the windows and the sound absorption in the room. If measurements are available, the measured values should be inserted.

For noise inside non-residential premises, criteria are proposed in Table 7 according to the different purposes of the rooms, as long as no higher values can be derived for the local site by the criteria given in section 4, corrected according to Table 6.

These values refer mainly to room noises which originate outside the room.

TABLE 7 – Examples for suggested noise criteria for non-residential rooms

Type of room	Noise criterion dB(A)
Larger office, business store, department store, meeting room, quiet restaurant	35
Larger restaurant, secretarial office (with typewriter)	45
Larger typing halls	55
Workshops (according to intended use)	45 to 75

EXHIBIT 4

COPIED FROM: INFORMATION ON LEVELS OF ENVIRONMENTAL NOISE REQUISITE TO PROTECT THE PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY, U.S. EPA.

Impulse Noise

It is difficult to identify a single-number limit requisite to protect against adverse effects from impulse noise because it is essential to take into account the circumstances of exposure, the type of impulse, the effective duration, and the number of daily exposures, (see Appendix G).

Hearing

Review of temporary threshold shift data leads to the conclusion that the impulse noise limit requisite to prevent more than a 5 dB permanent hearing loss at 4000 Hz after 10 years of daily exposure is a peak sound pressure level (SPL) of 145 dB. This level applies in the case of isolated events, irrespective of the type, duration, or incidence at the ear. However, for duration of 25 microseconds or less, a peak level of 167 dB SPL would produce the same effect, (see Figure 4).

1. Duration Correction: When the duration of the impulse is less than 25 microseconds, no correction for duration is necessary. For durations exceeding 25 microseconds, the level should be reduced in accordance with the "modified CHABA limit" shown in Figure 4 and Figure G-1 of Appendix G.

2. Correction for Number of Impulses:

Number of impulses per day:	1	10	100	10^3	10^4	
Correction factor:	0	-10	-20	-30	-40	dB

(More detailed information is provided in Figure 4.)

Furthermore, if the average interval between repeated impulses is between 1 and 10 seconds, a third correction factor of -5 dB is applied. Thus, to prevent hearing loss due to impulse noise, the identified level is 145 dB SPL, or 167 dB peak SPL for impulses less than 25 microseconds, for one impulse daily. For longer durations or more frequent exposures, the equivalent levels are as shown in Figure 4.

3

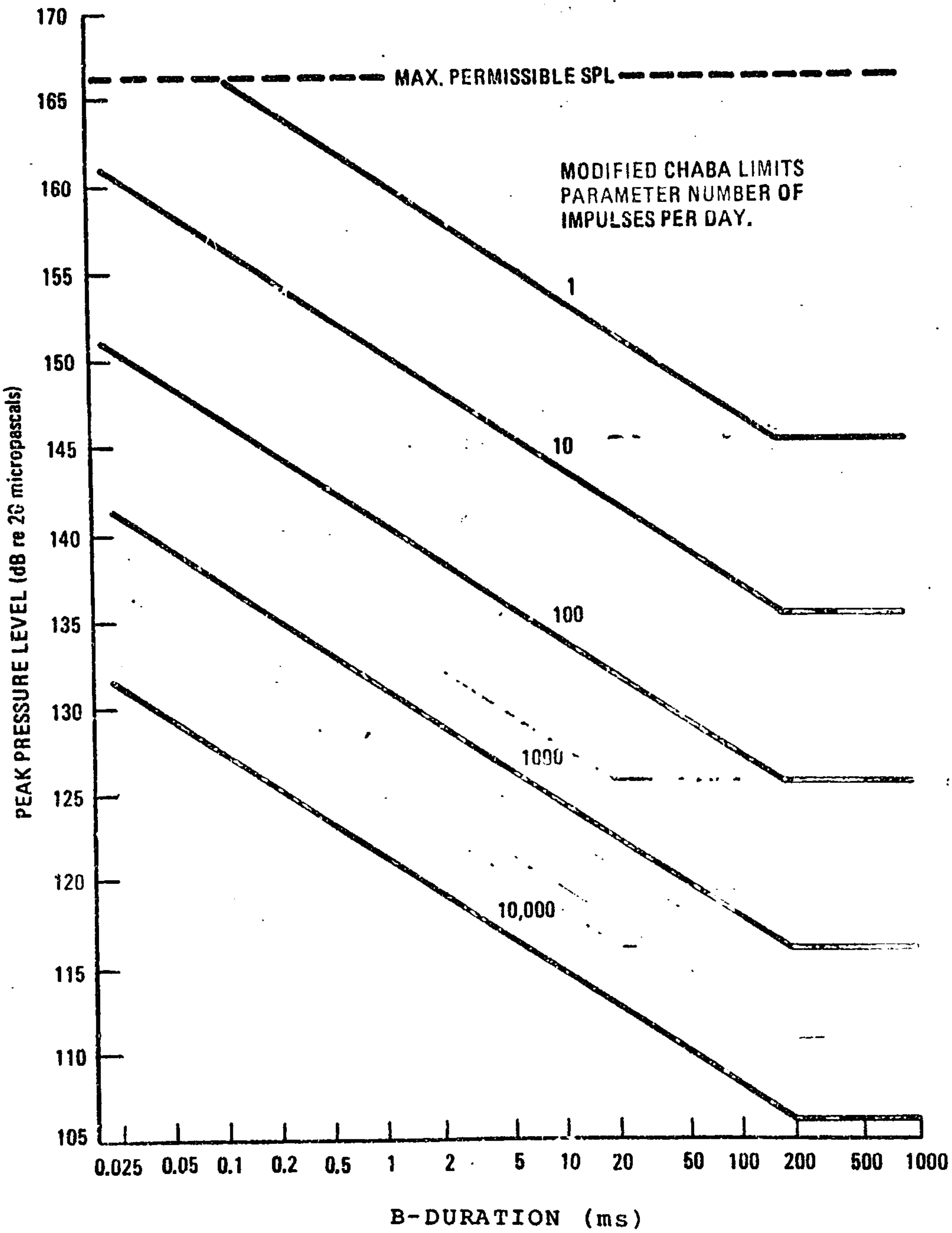

Figure 4. Set of Modified CHABA Limits for Daily Exposure to Impulse Noises Having B-Durations in the Range 25 Microseconds to 1 Second. (Parameter: number (N) of impulses per daily exposure. Criterion: NIPTS not to exceed 5 dB at 4 kHz in more than 10% of people.)

(Derived from Appendix G)

Non-Auditory Effects of Impulsive Sound

Impulses exceeding the background noise by more than about 10 dB are potentially startling or sleep-disturbing. If repeated, impulsive noises can be disturbing to some individuals if heard at all *(they may be at levels below the average noise levels).* However, no threshold level can be identified at this time; nor is there any clear evidence or documentation of any permanent effect on public health and welfare.

Sonic Booms

Little or no public annoyance is expected to result from one sonic boom during the daytime below the level of 35.91 pascals (0.75 pounds per square foot) as measured on the ground (see Appendix G). The same low probability of annoyance is expected to occur for more than one boom per day if the peak level of each boom is no greater than:

$$\text{Peak Level} = \frac{35.91}{\sqrt{N}} \text{ pascals}$$

Where N is the number of booms. This value is in agreement with the equal energy concept.