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CODE OF PRACTICE FOR NOISE REDUCTION IN INDUSTRIAL BUILDINGS

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 5

May 1966

Indian Standard
CODE OF PRACTICE FOR NOISE REDUCTION IN INDUSTRIAL BUILDINGS

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Indian Standard

CODE OF PRACTICE FOR NOISE REDUCTION IN INDUSTRIAL BUILDINGS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 8 December 1965, after the draft finalized by the Functional Requirements in Buildings Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 High noise levels are generally prevalent in industrial buildings. The amount of noise depends on the type of machines installed and industrial operations carried on and also the way power is applied and transmitted. Since for similar machines or operations the noise will be generally proportional to the power used, it follows that the trend towards bigger and faster machines will make the problem of noise in industry more and more serious unless effective measures are taken to reduce the noise. The harmful effects of excessive noise have been well recognized and it has been shown that such noise produces physiological and psychological effects on industrial workers, for example, annoyance, fatigue and loss of hearing. It is always advisable to give due consideration to noise reduction measures at the planning stage itself in order to obviate excessive expenditure on corrective measures later on. This standard is intended to indicate the types and sources of industrial noises, acceptable limits of noises, general principles involved in their study and methods for reducing them.

0.3 In situations where the noise levels cannot be reduced to acceptable limits, protection of workers would be necessitated with the use of ear-plugs, ear-defenders, etc. This standard does not include provisions for such situations. Further, this standard also does not include measures required for protecting the neighbourhood community from industrial noise.

0.4 In the formulation of this standard, due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in this field in this country. This has been met by deriving assistance from the following publication:

UNITED KINGDOM. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH. Factory building studies No. 6, 1960. H M Stationery Office, London.

0.5 The noise levels indicated for different types of industries in this standard are based on a study made by the Central Building Research Institute, Roorkee.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the types and sources of industrial noise and acceptable limits of noise levels in factories, machine shops and other industrial buildings and recommends the required noise reduction measures.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Bel — Bel is the fundamental division of a logarithmic scale used to express the ratio of two specified or implied quantities, the number of bels denoting such a ratio being the logarithm to the base 10 of this ratio.

2.1.1 *Decibel* (*dB*) — It is one-tenth of a bel.

Example:

$$\text{Sound power level} = 10 \log_{10} \frac{W}{W_0} \text{ in decibels, dB}$$

$$\text{Sound pressure level} = 20 \log_{10} \frac{p}{p_0} \text{ in decibels, dB}$$

where

W = measured acoustical power;

W_0 = reference acoustical power, expressed in the same units as W;

p = measured sound pressure; and

p_0 = reference sound pressure, expressed in the same units as p.

2.2 Frequency or Pitch — Frequency is the number of vibrations per second while pitch is the frequency sensation as perceived by a human ear. Pitch is defined as that aspect of auditory sensation in terms of which sounds may be arranged on a scale extending from ' low ' to ' high ' as a musical scale.

*Rules for rounding off numerical values (*revised*).

2.3 Intensity — Intensity at a point is the average rate at which sound energy is transmitted through a unit or around the point and perpendicular to the direction of propagation of sound.

2.4 Loudness — Loudness is the sensation produced in the human ear and it depends on the intensity of sound and also its frequency.

2.5 Noise — Noise is defined as unwanted sound.

2.6 Octave-Band Noise Levels — Noise is usually measured in groups of frequencies. A convenient grouping is $f_0 - 2f_0$, $2f_0 - 4f_0$, $4f_0 - 8f_0$, etc. These are called octave bands.

3. TYPES OF INDUSTRIAL NOISE

3.1 General — The distinction between noise and intelligible sound is purely subjective. A sound judged intelligible by one person may well be just a noise to his neighbour. As for instance, conversation between two persons may appear as disturbing noise to a third person who requires privacy or who may be engaged in a serious meditative work. Noise is not always a nuisance. For instance, in an office building beside a busy street a background ' humming noise ' is present which submerges many of the occasional disturbing sounds which in the absence of the above noise will appear too prominent and disturbing to the occupants.

3.2 Indoor Noise — Noises in industrial buildings are mainly of indoor origin. These are caused by the machinery in operation and the work processes involved.

3.3 Continuous and Impulsive Noise — Sound may be continuous, when the source is constantly vibrating, or as with many industrial noises, it may be impulsive in character, the source being set in vibration only for a short time. For instance sound from a drop forge hammer belongs to the latter category. Here the high intensity pressure waves die away fast although the peak levels attained are very high.

4. FREQUENCY DISTRIBUTION OF NOISE

4.1 Industrial noises are spread over the whole audio range of frequency from 20 to 15 000 c/s. The distribution of noise energy over the audio range, that is, its spectral distribution is of great importance in noise reduction.

4.2 Octave-Band Noise Levels — Frequency grouping commonly used for octave bands may generally be 37·5-75, 75-150, 150-300, 300-600, 600-1 200, 1 200-2 400, 2 400-4 800 and 4 800-9 600 c/s. The intensity of noise in each of these bands is measured not only to determine the overall noise level, but also to assess the characteristics required of an efficient noise reducing device. These band levels are essential for estimating damage risk, loudness level and speech interference level.

5. SOURCES OF INDUSTRIAL NOISE

5.1 The most intense noise in factories and workshops is generally caused by machine tools and by operations involved in making and handling the product. For the purpose of this standard the source of this noise shall be classified into following groups, depending on how the noise energy is generated.

5.1.1 *Impact* — Noise caused by impact is the most intense and wide spread of all industrial noises. It is normally coupled with resonant response of the structural members connected to the impacting surface. Common sources of this type of noise are forging, riveting, chipping, pressing, tumbling, cutting, weaving, etc. Intense impact noise may also be produced during handling of material as in the case of sheared steel plates falling one over another in collecting trays in a steel factory. The spectrum of noise depends on the nature and size of the object being worked, as well as on the tool. Impact noise is usually impulsive in character, but it can also be continuous as in the case of tumbling.

5.1.2 *Friction* — Most of the noise due to friction is produced in such process as sawing, grinding, and sanding. Friction also occurs at the cutting edge on lathes and other machine tools and in brakes and badly lubricated bearings. The spectrum of frictional noise often predominates in high frequency and is very unpleasant in character.

5.1.3 *Reciprocation* — Where a machine vibrates or reciprocates as in the case of a vibration shake out in a foundry or imbalance in rotating machinery, the moving surface will radiate noise directly.

5.1.4 *Air Turbulence* — Noise may be generated by rapid variation in air pressure caused by turbulence from high velocity air, steam or gases. Common examples are the exhaust noise from pneumatic tools and jet engines. The noise is intense, especially at high frequencies. The intensity increases rapidly with the velocity of the air stream.

5.1.5 *Other Noises* — In addition, there are other noises as well, such as whinning noise from turbines and humming noise from transformers.

6. MEASUREMENT OF NOISE

6.1 Intensity levels in the different octave bands are measured by a sound level meter in conjunction with octave-band filters.

6.1.1 The noises are picked up by a high quality microphone, passed through an octave-band filter and the sound pressure levels recorded on a level recorder. Alternatively, noises may be recorded on a magnetic tape recorder for subsequent analysis. It must be ensured that the measuring or the recording system has a substantially uniform frequency response over the entire audio frequency range.

6.1.2 Impact noises, which are highly complex in nature, are measured with an 'impact noise analyser' and also simultaneously recorded on a magnetic tape recorder to facilitate octave-band analysis. It is also sometimes displayed on oscilloscope screen.

6.1.3 As the noise levels are not the same at all locations inside the factory or workshop, the levels are measured mostly at locations enveloped by high intensity noises. Also while determining damage risk, it is necessary to measure the noise levels as close to the operator's ear position as possible.

7. NOISE CHARACTERISTIC

7.1 Range of noise levels generated in a variety of industrial operations are given in Appendix A. Typical spectra for a few common operations and pneumatic tools are shown in Fig. 1 to 4.

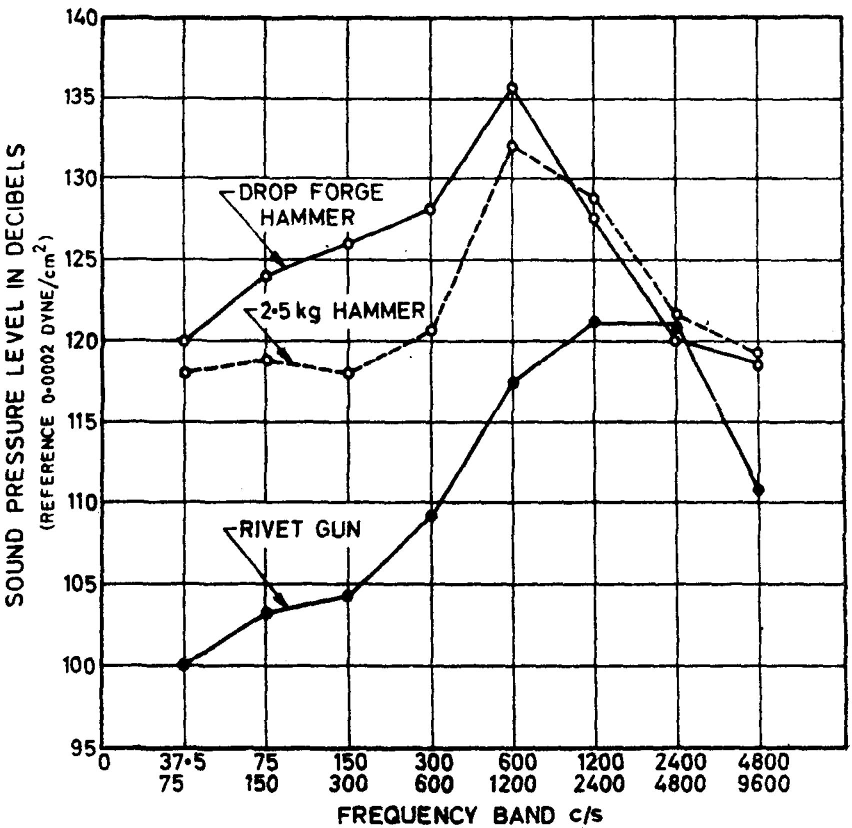


FIG. 1 NOISE LEVELS MEASURED AT THE OPERATOR POSITION FOR TYPICAL HAMMERING AND RIVETING OPERATIONS

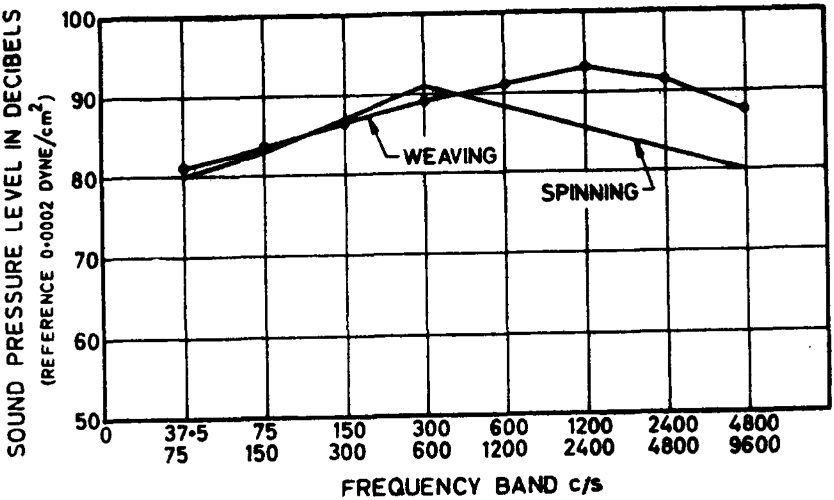


FIG. 2 NOISE LEVELS MEASURED AT OPERATOR POSITION IN TEXTILE WEAVING AND SPINNING PLANTS

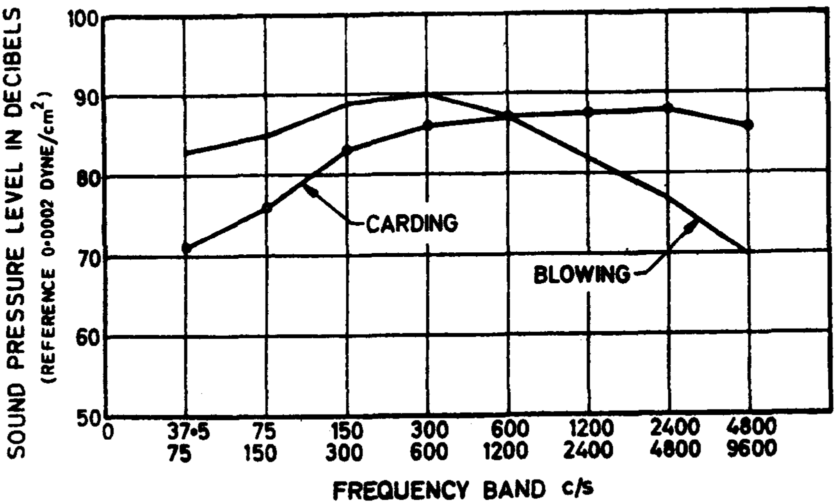


FIG. 3 NOISE LEVELS OF CARDING AND BLOWING PROCESSES IN TEXTILE MILLS

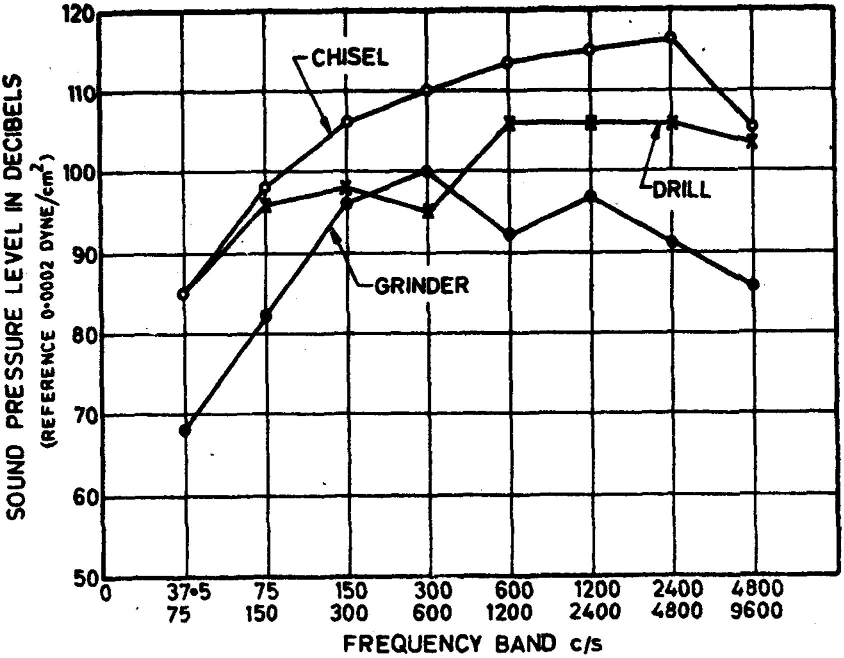


FIG. 4 NOISE LEVELS MEASURED AT THE OPERATOR POSITIONS OF SEVERAL PNEUMATIC TOOLS

8. NOISE CRITERIA

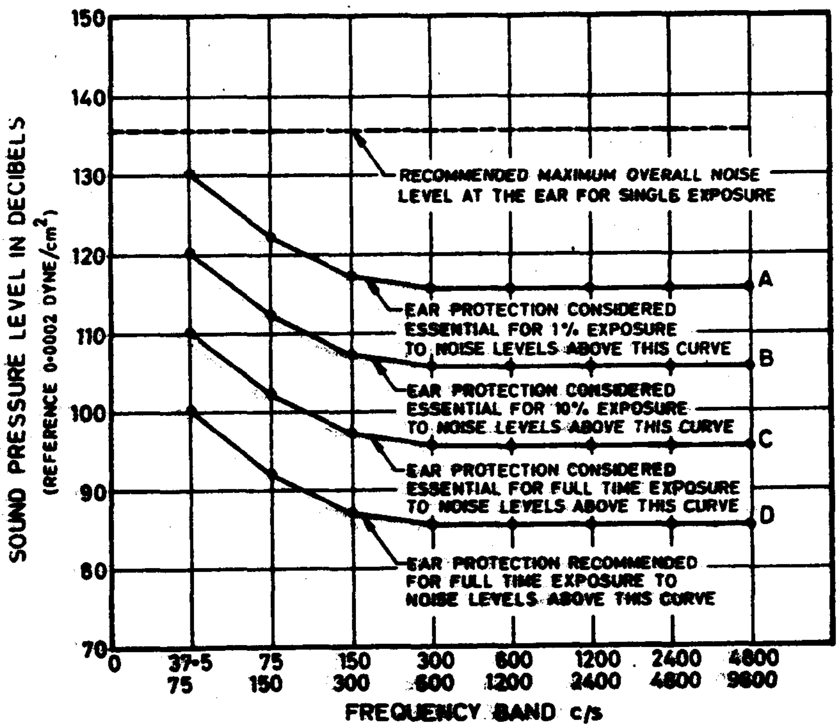
8.1 Damage-Risk Criteria — Damage-risk criteria specify the maximum levels and duration of noise exposure that can be considered safe. Generally accepted damage-risk criteria for exposure to continuous, steady broad band noise, for eight hours six-day week, are shown by the octave-band noise level curves of Fig. 5. Noise criteria for hearing preservation in terms of the average length of exposure time each day to various average noise levels are also given in Fig. 6. Whenever the noise intensity at the workers position in a factory exceeds the levels and duration suggested by criterion curves, ear protection is recommended, since exposure to such high intensity noises may result in permanent auditory damage in the course of time.

8.2 Interference with Communication — In factories where audible warning signals are used, or where an operator follows the operation of his machine by ear, the background noise should not be so loud as to mask the signal or desired sound (the 'information sound') to be heard.

9. METHODS OF REDUCING NOISE

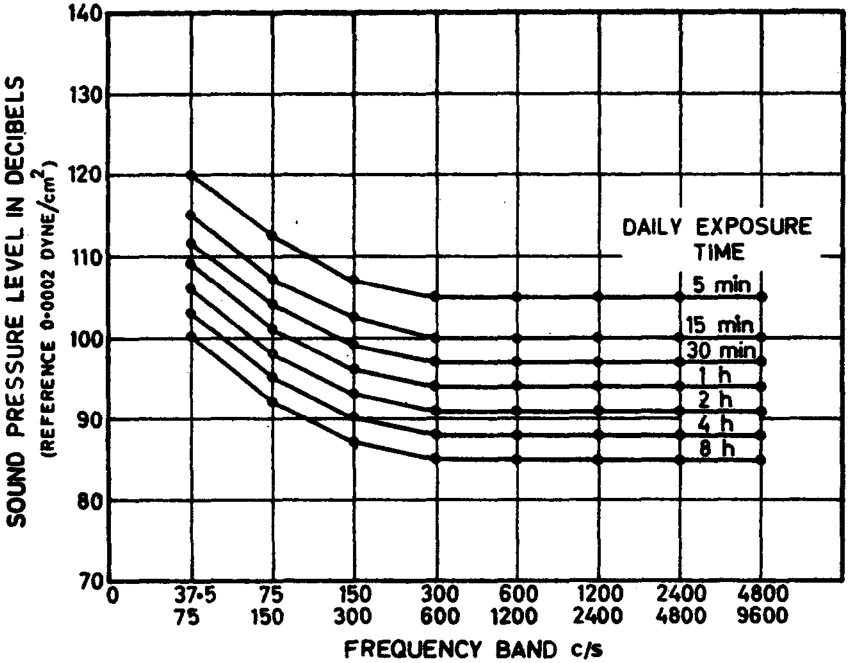
9.1 Noise Control by Location — Machines, processes and work areas which are approximately equally noisy should be located together. Areas that are particularly noisy should be segregated from quiet areas by buffer zones that produce and can tolerate intermediate noise levels.

9.2 Noise Reduction by Layout — The office space in a factory should be as far as possible segregated from the production area and located preferably in a separate building. This building should not have a wall common with the production area. Where a common wall is unavoidable, it should be heavy with few connecting doors and no permanent openings.



NOTE — The time parameter of the curves marked *A* and *B* is the percentage of each working day.

FIG. 5 BROAD BAND NOISE LEVEL EXPOSURES FOR WHICH CONSERVATION-OF-HEARING MEASURES ARE RECOMMENDED OR CONSIDERED ESSENTIAL



NOTE 1 — For levels 10 dB, or higher than those shown hearing preservation procedures are considered essential.

NOTE 2 — These curves are built on the lowest curve of Fig. 5 assuming that a halving of the daily exposure permits 3 dB higher noise levels.

FIG. 6 HEARING PRESERVATION CRITERIA FOR USE IN NOISE CONTROL DESIGN FOR BROAD BAND NOISE LEVELS OF VARIOUS AVERAGE DAILY EXPOSURE TIMES

9.3 Noise Reduction at Source

9.3.1 *Selection of Machinery* — Noise should be reduced as near the source as possible so that the acoustical treatment is less expensive and a large number of people are protected from the noise. While the operational processes in a factory may be fixed and may have no quieter alternative, careful selection of the machine tools and equipment to be used may considerably help attaining lower noise levels in the machine shop. One make of machine tool may have noisy mechanical system compared with another of similar performance.

9.3.2 *Reducing Noise from Potential Sources* — Impact that is not essential to a process should be quietened. Noise from handling and dropping of materials on hard surfaces may be reduced by using soft resilient materials on containers, fixing rubber tyres on trucks, trolleys, etc. Machine noise may be kept to a minimum by proper maintenance. Proper lubrication will reduce noise by friction, conveyor, rollers, etc.

9.3.3 The noise from the radiating surfaces can be reduced by reducing the radiating area. For example, if the area is halved, the noise intensity will be reduced by three dB, and at low frequencies the reduction will be much greater.

Supporting structures for vibrating machines and other equipment should be frames rather than cabinets or sheeted enclosures. If an enclosure is used, precaution should be taken to isolate it and line it on the inside with sound-absorbent material. The noise radiated by machinery guards can be minimized by making them of perforated sheet or of wire mesh.

9.3.4 *Reducing Transmission of Mechanical Vibrations* — A vibrating source does not usually contain a large radiating surface but the vibration is conducted along mechanically rigid paths to surfaces that can act as effective radiator. If the rigid connecting paths are interrupted by resilient material, the transmission of vibration and consequently the noise radiated may be greately reduced. The reduction depends on the ratio of the driving (forcing) frequency of the source to the natural frequency of the resilient system. The natural frequency may be determined from static deflection under actual load as given in Fig. 7. The higher the ratio between the two ferquencies, the less is the transmissibility, which is defined as the ratio of the displacement transmitted through the resilient isolator to the exciting displacement applied to it. Transmissibility and the equivalent noise reduction for various frequency ratios are given in Fig. 8. For satisfactory operation, a ratio of 3 : 1 or more between the driving and natural frequencies is recommended.

9.3.4.1 *Material for isolators* — Vibration isolators are usually made of resilient materials like steel in the form of springs, rubber, cork and felt.

Because of the large range of deflections obtainable in coil springs, they may isolate vibrations over a large spectrum of low frequencies. Metal springs transmit high frequencies (from about two hundred to several thousand c/s) very readily. Transmission of these frequencies can be reduced by eliminating direct contact between the spring and the supporting structure. Rubber or felt pads may be inserted between the ends of the spring and the surfaces to which it is fastened.

Rubber pads may be used to isolate very effectively, relatively small machinery, engines, motors, etc. It may be used in compression or in shear. Some rubber mountings use rubber-in-shear as the primary elastic elements and rubber-in-compression as a secondary element which furnishes snubbing action if the mounting is subjected to an overload.

Felt or cork or both may be used as resilient mats or pads under machine bases. The load per unit area shall be chosen to produce enough deflection for the isolation required; and shall be such that at this deflection, it is not loaded beyond its elastic limit.

9.3.4.2 *Position of isolator* — The normal position of the isolators is between the machine and its foundation. However, if the forcing frequency of the machine is low (less than 10 c/s) and vibration isolators with the requisite deflections for this location are not available, the machine may be bolted directly to an independent heavy inertia concrete base and the available vibration isolators used below the concrete base.

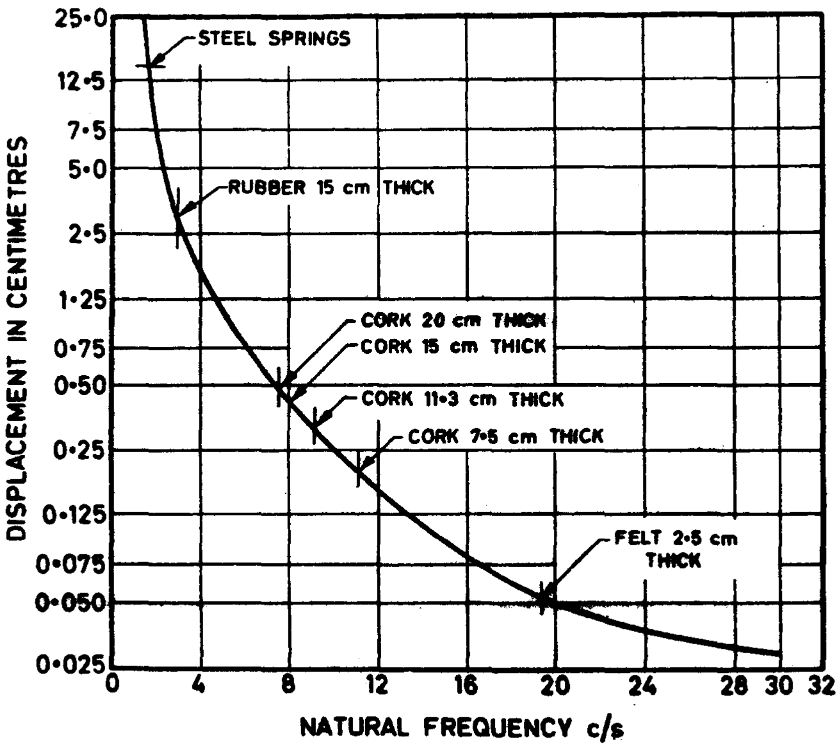


FIG. 7 RELATION BETWEEN STATIC DEFLECTION AND NATURAL FREQUENCY

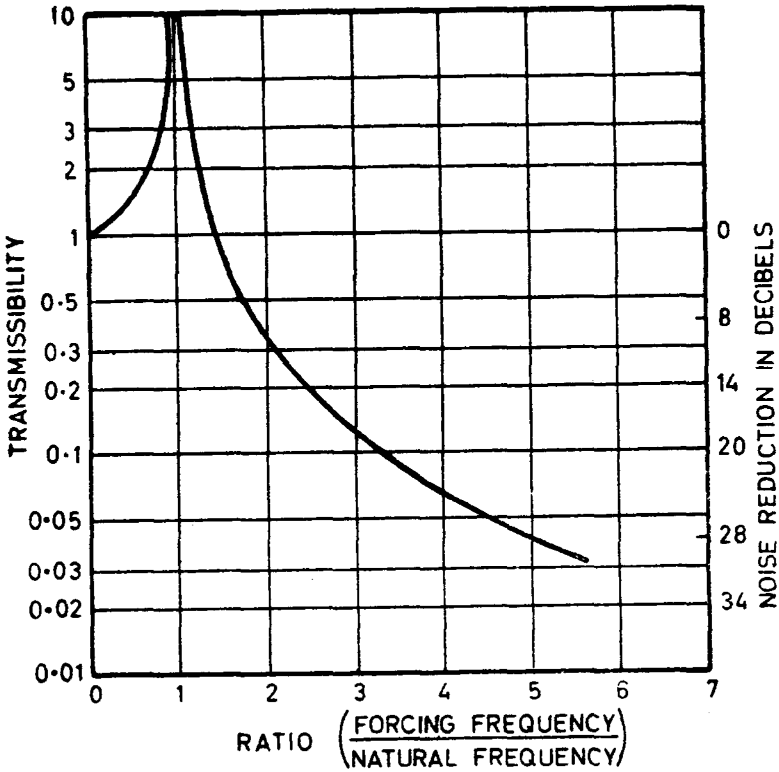


FIG. 8 TRANSMISSIBILITY AND EQUIVALENT NOISE REDUCTION FOR DIFFERENT RATIOS OF FORCING AND NATURAL FREQUENCIES

Large press, drop hammers which create serious impact vibration in heavy machine shops, may be mounted rigidly on very massive blocks of concrete having weights many times greater than the weights of the supported machines. The inertia blocks may, in turn, be isolated from the building structure by large wooden blocks and with thick pads of cork.

In critical installations, attempt should be made to locate the resilient mounts in a plane which contains the centre of gravity of the mounted assembly. It is also preferable to locate the mounts laterally as far away as possible from the centre of the machine.

NOTE — Critical installations are those installations where transmission of vibration from these installations will seriously hamper the normal working.

Rigid mechanical ties between vibrating machine and building structure short circuit or reduce, the effectiveness of isolators. Loose and flexible connections should be inserted in all pipes and conduits leading from the vibrating machine. Where flexible connections are impracticable, bends should be inserted into the pipes or the pipes themselves should be supported on vibration mounts for a considerable distance from the source.

9.4 Noise Reduction by Enclosures and Barriers

9.4.1 *Enclosures* — Air-borne noise generated by a machine may be reduced by placing the machine in an enclosure or behind a barrier. Much larger noise reduction can be achieved with complete enclosures. The enclosure may be in the form of close-fitting acoustic box around the machine such that the operator performs his normal work outside the box and thus is not subjected to the high noise levels of the machine. The enclosure may also be made of sheet metal lined inside with an acoustical material.

Where size of the machine and working area and the operation do not permit close-fitting enclosures, the machine may be housed in a room of its own. The inside of the enclosure should be lined with sound-absorbing materials to reduce the noise level of the contained sound. The bounding walls of the enclosures shall also have adequate transmission loss to provide proper sound insulation (*see* IS : 1950-1962*).

9.4.2 *Barriers* — A partial reduction of noise in certain directions may be obtained by 'barriers' or partial enclosures or partial height walls. Two-sided or three-sided barrier, with or without a top (*see* Fig. 9) and invariably covered on the machine side with acoustic absorption material may affect appreciable noise reduction. Where it is possible, the opening should face a wall covered with sound-absorbing material. If the top of the enclosure is open, the reduction may be increased by placing sound-absorbing material on the ceiling overhead.

10. ACOUSTICAL ABSORPTION DEVICES

10.1 Acoustical Treatment of Ceilings and Side Walls — In order to reduce the general reverberant noise level in machine shops, acoustical material may be placed on the ceiling and side walls. With this treatment three to eight dB reduction of middle and high frequency noise may be achieved. While the noise level at the source, affecting the operator, may not be reduced materially, the treatment would bring down the general reverberant noise level and, as a consequence, the noise conditions may become less confusing.

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*Code of practice for sound insulation of non-industrial buildings.

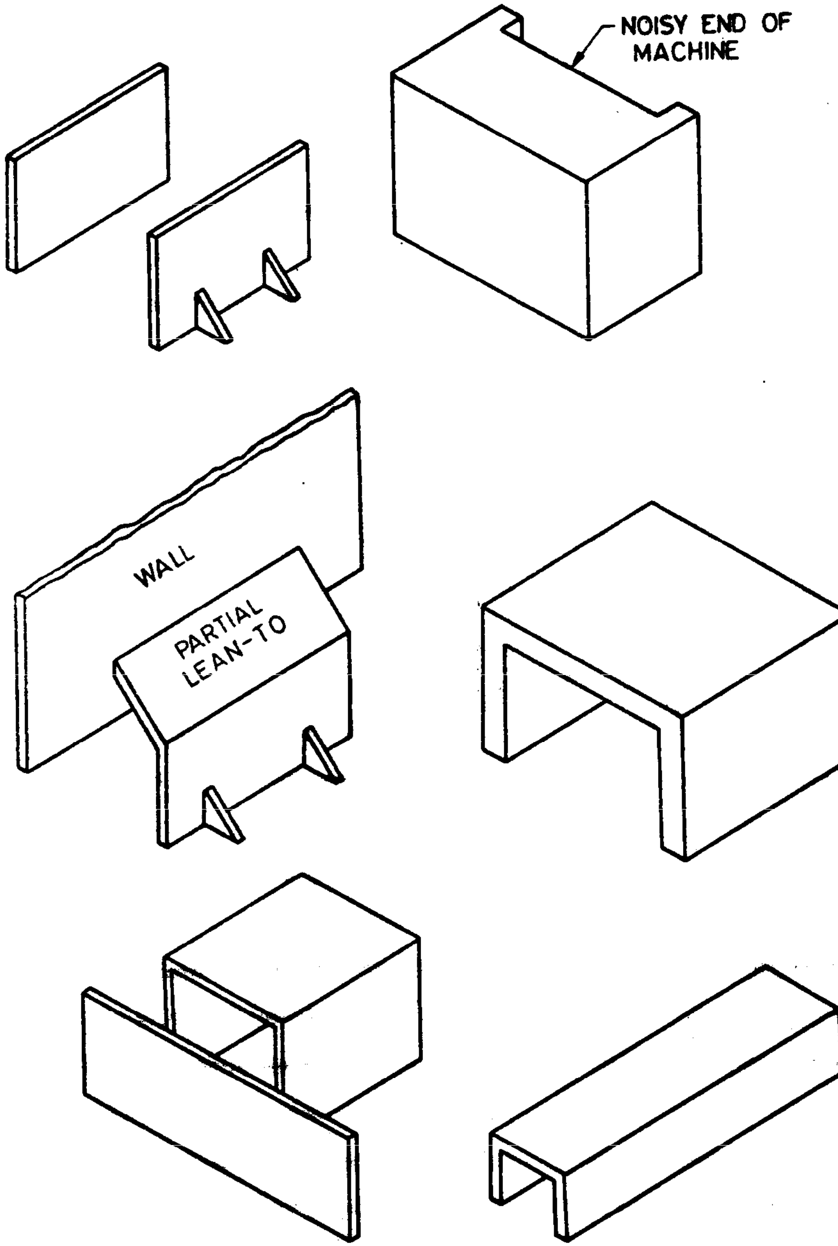


Fig. 9 Typical Barriers for Partial Noise Reduction

10.2 Functional Sound Absorbers — For efficient noise reduction 'functional sound absorbers' may be clustered as near the machines as possible. These units may be suspended and distributed in any pattern to obtain lower noise levels within the machine shop. Compared on the basis of equal total exposed surface areas, functional sound absorbers have slightly higher noise reduction coefficients (arithmetic average of absorption coefficients at 250, 500, 1 000 and 2 000 c/s) than conventional acoustical materials placed directly on ceilings and walls. Details of a typical functional absorber are shown in Fig. 10. Data on some typical units of functional absorber are given in Appendix B. These units utilize fibre glass as absorbent material. Other materials may also be used for fabricating such units.

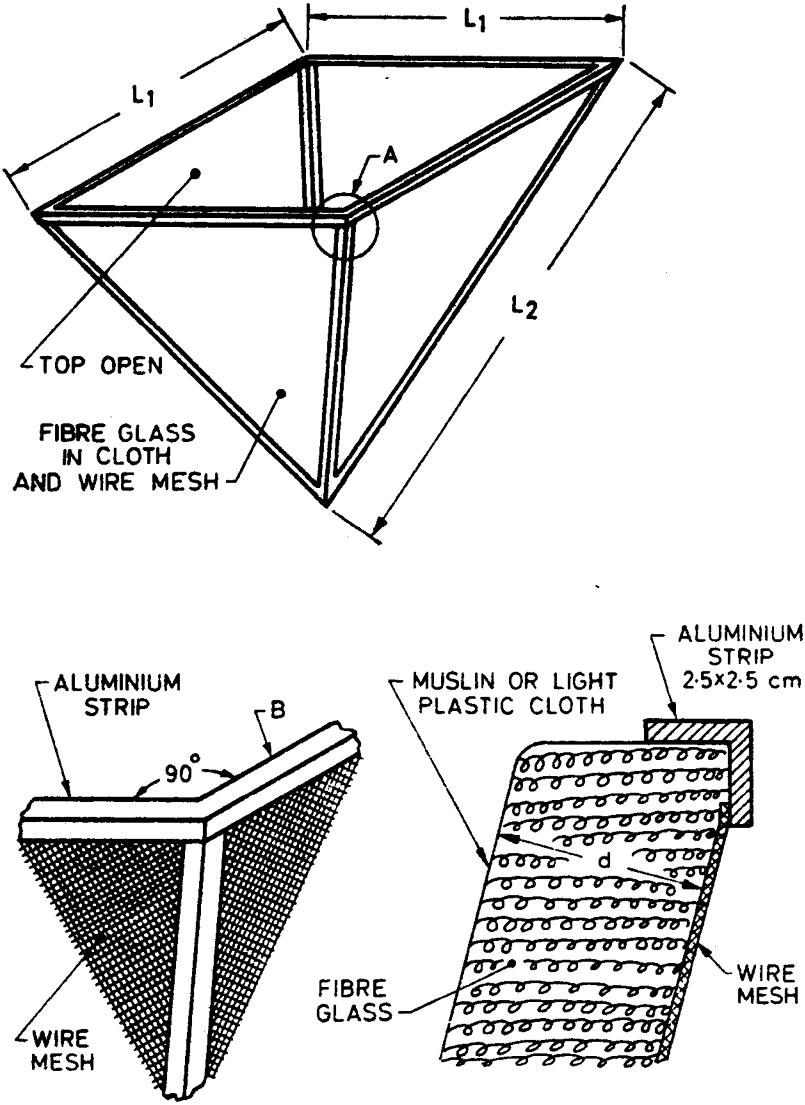
APPENDIX A

(*Clause* 7.1)

RANGE OF LOUDNESS LEVELS FOR VARIOUS INDUSTRIAL OPERATIONS

Source	Loudness Level Phons
Mills; cotton, silk, woollen (spinning, weaving, carding)	90 to 110
Sugar mills (crushing)	105 to 110
Steel rolling	95 to 105
Drop forge hammer	130 to 145
Steel bar shearing	110 to 125
Riveting (steel plates)	105 to 110
Riveting and chipping (large steel plates)	120 to 130
Circular saw (wood)	100 to 110
Wood planing	115 to 120
Jolting	115 to 120

Note — *In all these cases the noise levels refer to the values prevailing close to the noise sources.*



Detail at A | **Sectional Detail at B**

NOTE 1 — L_1 and L_2 are usually 75 to 90 cm. Larger values may be taken for frequencies below 300 c/s.

NOTE 2 — d is usually 5 to 7·5 cm. Larger values may be taken for frequencies below 300 c/s.

FIG. 10 FUNCTIONAL SOUND ABSORBERS (TYPICAL UNIT)

APPENDIX B

(*Clause* 10.2)

ABSORPTION COEFFICIENT OF TYPICAL FUNCTIONAL SOUND ABSORBERS COMPARED TO A FLAT AREA OF THE ABSORBING MATERIAL

Sl No.	Description	Values of Absorption Coefficient for Various Frequencies (c/s)					Noise Reduction Coefficient for Frequency Range of 250-2 000 (c/s)
		250	500	1 000	2 000	4 000	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	*Flat Area*						
	a) Fibre glass* 2·5 cm thick with rigid backing	0·43	0·69	0·80	0·86	0·54	0·70
	b) Fibre glass* 5 cm thick with rigid backing	0·76	1·04	0·75	1·15	0·85	0·93
ii)	*Functional Sound Absorber*						
	a) Functional absorber units, pyramidal in shape and having as absorbing material fibre glass*:						
	2·5 cm thick	0·52	0·55	0·98	1·57	1·1	0·91
	5 cm thick	1·14	1·22	1·63	1·58	1·54	1·39
	b) Functional absorber units, rectangular in shape and having as absorbing material fibre glass*:						
	2·5 cm thick	0·30	0·45	0·82	0·81	0·95	0·6
	5 cm thick	0·78	1·15	1·41	1·36	1·41	1·18

*Packing density of fibre glass used is 70 kg/cm³.

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53/5, Ward No. 29, R.G. Barua Road, 5th Byelane, GUWAHATI 781003	3 31 77
5-8-56C L. N. Gupta Marg (Nampally Station Road), HYDERABAD 500001	23 10 83
R14 Yudhister Marg, C Scheme, JAIPUR 302005	6 34 71 6 98 32
117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
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