APPENDIX

A NOISE LIMIT LEVELS:

A.1 General

A.1.1 Noise limits should be laid down as a function of the goal to be attained, in particular:-

(a) to prevent a risk of hearing impairment

(b) to prevent interference with communications essential for safety purposes

(c) to eliminate nervous fatigue, with due regard to the work to be done

A.1.2 The noise limit levels should be reviewed from time to time so as to keep abreast of scientific knowledge, technical developments and possibilities of prevention.

A.2 Hearing impairment

A.2.1 Depending on the degree of protection wanted, the following limit values should be determined:-

(a) a warning limit value that sets the noise level below which there is very little risk of hearing impairment to an unprotected ear for an eight hour exposure

(b) a danger limit value that sets the noise level above which hearing impairment and deafness may result from an eight-hour daily exposure of an unprotected ear

A.2.2 In the light of present knowledge, the following values may be recommended:-

(a) a warning limit value of 85 dB (A)

(b) a danger limit value of 90 dB (A)

A.3 Special provisions

A.3.1 During emergencies, or because of unforeseen technical imperatives, a worker may be temporarily authorised to exceed the daily dose, provided that the next day he recuperates so that the maximum weekly dose is respected. (ie. seven times the maximum daily dose).

A.3.2 No matter for how short a time a worker should not, without appropriate ear protection, enter an area in which the noise level is 115 dB(A) or more.

A.3.3 If there are single isolated bursts of noise which can go above 130 dB(A) or 120 dB(A), personal protective equipment should be worn.

A.3.4 No worker should enter an area where the noise level exceeds 140 dB(A).

A.4 Ultrasound and Infrasound

A.4.1 A survey should be made to find out if any workers are exposed to ultrasound and infrasound in their place of work.

A.4.2 Levels of exposure to ultrasound and infrasound should be reduced to and kept at a reasonable value, due account being taken of up-to-date technical information available.

NOTE: Infrasound is acoustic oscillation whose frequency is too low to affect the sense of hearing in man. It has a frequency range from 0 to 20 Hz. It has the following effects:-

(a) Cochleo-vestibular effects: pain which occurs at an intensity of 165 dB at a frequency of 3 Hz; and of 140 dB at a frequency of 15 Hz.

(b) General effects: the appearence of changes in rate of respiration, skin tension, vision disorders in the vicinity of 10 Hz, fatigue and somnolence.

Ultrasound is acoustic oscillation whose frequency is too high to affect the sense of hearing in man. It has a frequency range above 20,000 Hz.

A.5 Oral communications

The noise limits expressed in dB (A) at places of work concerned and for the kind of oral communications envisaged, should be determined with regard to the current technical knowledge available.

A.6 Fatigue and comfort

A.6.1 (a) Hearing conservation should be an important factor in the improvement of the working environment

(b) The noise levels laid down should be such that work can proceed normally with a minimum of fatigue and discomfort

(c) In defining these noise levels due account should be taken of the kind of work being done and the available knowledge

A.6.2 The noise levels determined should ensure adequate comfort and be considered as objectives to be aimed at.

(SOURCE : "Noise in Industry" - C.I.S. Information sheet No. 17,1968)

B SOUND INSULATION VS. ABSORPTION:

The distinct functions of sound insulation (the prevention of transmission of sound) and sound absorption (the prevention of reflection of sound) must not be confused.

Sound insulation is the term given to the reduction obtained when sound passes from one room to another room or from one side of a partition (wall, floor, roof, etc) to the other side; it is a function of the whole construction of the partition influenced by the surrounding structure, etc.

Sound absorption is the term given to the loss of sound energy on reflection at a surface; it is mainly a property of the surface construction or material.

There is a direct relationship between the sound insulation value of a partition and the sound absorption of its surfaces. It is true that the proportion of sound transmitted through a partition contributes normally, with the proportion absorbed as heat, in preventing reflection of sound from the surface, but the transmitted portion is so small as to be of no account in absorption. For instance, a single sheet of hardboard which is relatively poor for sound insulation (an insulation of 20dB) only transmits 1 per cent of the incident sound, whereas absorption coefficients are not usually calculated with a greater accuracy than to the nearest 5 per cent.

However, there are several ways in which the absorption of sound can affect, or be used to implement, sound insulation. The amount of absorption present in a room affects the level of the transmitted noise; this is not strictly a feature of the sound insulation of the structure at all, but it will appear to be so. Changes in noise level due to absorbent treatment of the room surfaces are usually small relative to the sound insulation. The degree of absorption within the cavity of a double-leaf construction, such as a cavity wall or a double window, influences the sound insulation of that construction to some extent. An important contribution made by sound absorption to sound insulation occurs when there are air-paths, such as ventillation ducts, linking the rooms concerned and forming by-passes for sound; absorbent linings within the duct may reduce considerably the amount of sound transmitted along it. In all these cases, however, the absorbent material or surface construction functions by reducing reverberation and not by acting as an ordinary barrier.

B.1 Principles of airborne sound insulation

(a) Density

Because sound only exists as vibration it diminishes when it 'passes through' a barrier, say wall, due to the reduction sustained by the vibration in overcoming the inertia of the barrier. The heavier the barrier the more it will resist vibration and so a heavy wall is a more effective sound insulator than a light one.

(b) Uniformity

The efficiency of the sound insulation depends not only on weight but also on completeness and uniformity. If there is a hole in the barrier the sound energy or pressure is released and flows through the hole, like compressed gas from a cylinder. Apart from holes, areas of any weaker insulation in a barrier may have considerable influence on the net insulation.

(c) Discontinuous construction

A further means by which sound insulation can be increased is known as 'discontinuity'. It implies the separation of parts of a structure in such a way that sound vibrations are not easily transmitted from one part to another. Examples of this technique applied to buildings are the double wall, the fully isolated 'box' structure, the 'floating' floor, resilient machine mountings, etc. The importance of this means of sound insulation is considerable, but at the same time the difficulties, drawbacks and risks of the method are also very great and attempts at discontinuity have been responsible for a vast amount of unprofitable expenditure and disappointment due to lack of understanding of the principles involved. In this respect the case is similar to the incorrect use of sound absorbent materials as barriers in attempts to improve sound insulation. To apply discontinuity properly it is necessary to have full understanding of how sound gets from one room to another.

B.3 Noise reduction by sound absorbents

Noise within a room can be reduced in some measure by introducing sound absorbent surfaces. The level to which a sound of a given energy will build up is governed by the total sound absorption in the room. Doubling the amount of absorption reduces the energy by 3dB; a further doubling gives another 3 dB reduction, giving a total reduction of 6 dB. Obviously, there is an economical limit to noise reduction by sound absorbents. But the provision of sound absorbent in an otherwise reverberant room is nearly always worthwhile. It is usual to place most of the available treatment on the ceiling because this surface is frquently the nearest one to the noise source, and also the most exposed to it.

Absorbent treatments usually give most benefit in large rooms where the noise sources are confined to some parts of the room only and other parts have quieter activities; an absorbent ceiling reduces the spread of noise from the noisy area to the quiet one.

B.4 Background noise and masking

Background noise is the more-or-less continuous noise present due to internal activities or to unavoidable but familiar intruding noise such as traffic noise. The effect is to mask other sounds. Very often, of course, the masking noise interferes with the communication of speech or music and is a nuisance, but there are also times when the insulation of particular noises is desired and then the partial masking of those noises by accepted background noise is an advantage. The background noise in effect adds to the insulation by raising the threshold at which the unwanted noise begins to be heard or noticed.

The practical effect of masking by background noise is quite important. For instance, less insulation between rooms will suffice in town buildings subjected to continuous traffic noise than in quiet village buildings.

B.5 Speech interference levels

In speech communication it is the higher frequencies that determine intelligibility, and since the masking of one sound by another is greatest when both sounds are similar in frequency, interference with the hearing of speech arises mainly from the higher frequency components of the masking noise. For this reason a criterion called the "Speech Interference Level" (S.I.L.) has been devised and it is calculated simply by averaging arithmetically the octave-band noise levels (in dB) of the three octaves above 600 Hz, namely 600 - 1200, 1200 - 2400, and 2400 - 4800 Hz. Applying this criterion to hearing on the telephone, the following assessments have been made (Table XXX):-

TABLE XXX

SPEECH INTERFERENCE LEVELS FOR TELEPHONE USE

S.I.L. of masking noise (dB)	Telephone use
upto 45	satisfactory
45 - 60	slightly difficult
60 - 75	difficult
above 75	unsatisfactory

(Source: "Noise in Industry" - C.I.S. Information Sheet No:17,1968)

The maximum S.I.L. to permit satisfactory hearing of natural speech at various distances are given in table XXXI.

TABLE XXXI

MAXIMUM SPEECH INTERFERENCE LEVELS

Distance from Speaker (m)	Normal voice(dB)	Raised voice(dB)	Very loud voice(dB)	Shouting (dB)
0.15	71	77	83	89
0.30	65	71	77	83
0.60	59	65	71	77
0.90	55	61	67	73
1.20	53	59	65	71
1.50	51	57	63	69
1.80	49	55	61	67
3.60	43	49	55	61

(Source:"Noise in Industry" - C.I.S. Information Sheet No:17,1968)

Nevertheless, although the higher frequencies cause the most interference with speech, low-frequency noises must also be considered because noise has a greater masking effect on frequencies higher than its own than on frequencies below its own.

B.6 The effect of noises

The two most important factors are the intensity of noise and the duration of exposure. The noises that last longest are the most harmful, and in noisy trades the workmen who suffer most are those who have been exposed to the noise for the longest time.

Among other personal factors must be noted the part played by fatigue. Whereas noise may be tolerated, or even completely ignored, by those in good health, lowered physical or nervous health makes it impossible to bear up against the irritation and resulting fatigue caused by continuous loud noises.

The age of the sufferer must be taken into consideration with the increase of lesions and this is said to occur chiefly in occupations which involve laborious physical work such as men who carry heavy loads, and blacksmiths.

B.7 Sound Weighting Scales

Let us suppose we listen to a pure tone (a sound of a single frequency, eg. a whine or squeal) of 1000 Hz. and 40 dB sound pressure level (SPL), and that we carefully remember its loudness. If, now, we listen to another tone, this time of 100 Hz. i.e. lower in pitch, and adjust the level of the second sound until it is as loud as the first, we will find that the second sound has a higher SPL than the first - in fact it is about 50 dB.

This illustrates immediately that the loudness of a sound depends not only on its sound pressure level but also on its frequency: the ear has a 'frequency response'. The loudness of a tone of 1000 Hz. is said to have a value in 'phons' equal to its SPL; that is simply how phons are defined. Thus, the loudness of a tone of 40 dB at 1000 Hz. is said to be 40 phons and, as each point on the equal loudness contour (also called 'phon curve') passing through the 40 dB/1000 Hz point has the same loudness, the loudness of a tone of 50 dB at 100 Hz. is also 40 phons.

One approach to measuring sounds in a way reflecting on their loudness is to alter the measured frequency spectrum of the sound to take account of the fact that the ear responds less well to frequencies below 500 Hz and above 8000 Hz. than it does between those frequencies. Thus by subtracting some decibels from the lower and upper frequency bands while leaving them approximately the same elsewhere, and by then adding up the new levels in the bands, one can obtain a weighted sound level which to some extent correlates with the sound's loudness.

Three such weightings were originally proposed. For sounds that were "not loud", about 40 phons, the A weighting curve was defined. For sounds that were "moderately loud", about 70 phons, the B weighting curve was defined. For "loud sounds", about 100 phons, the C curve was defined, which is, like the 100 phon loudness contour, fairly flat; this meant that the lower and higher frequencies were not much deemphasized so that the C weighted decibel is rather similar to the overall sound pressure level itself.

The audible frequency range can be arbitrarily divided up into a series of adjacent frequency bands known as 'octave bands' for which the width of a given band as proportional to the centre frequency. Each of these can be further divided into three one-third octave bands, also of widths proportional of their centre frequencies. It is the similarity of these bandwidths to the ear's critical bandwidths that permit them to be used for calculating the loudness of composite sounds.

To calculate a weighted sound level, the sound is first analysed into octave or one-third octave bands, the latter being best for all sounds except those which have flat frequency spectra, i.e. have their energy fairly evenly distributed across the frequency bands. (For such sounds, an octave band analysis is adequate).

Although derived for sounds of varying degrees of intensity, it has been found that the A-weighted sound level is very useful at all levels of intensity. In contrast, the B-weighting scale is in virtual disuse. The C-weighting scale is also not used to reflect human response, but its not quite flat weighting curve permits it to be a reasonable approximation of the overall SPL. It is simpler to build a Sound Level Meter which gives a C-weighting than the overall SPL, because the C-weighting does not require as wide a frequency response. (Fig. 10)

A weighted sound level is written as dB (A) or dB A. dB (A), dB (B) and dB (C) can be read directly on many Sound Level Meters by switching in a set filters to produce the appropriate weighting.

Fig. 11 depicts a chart for adding decibels.

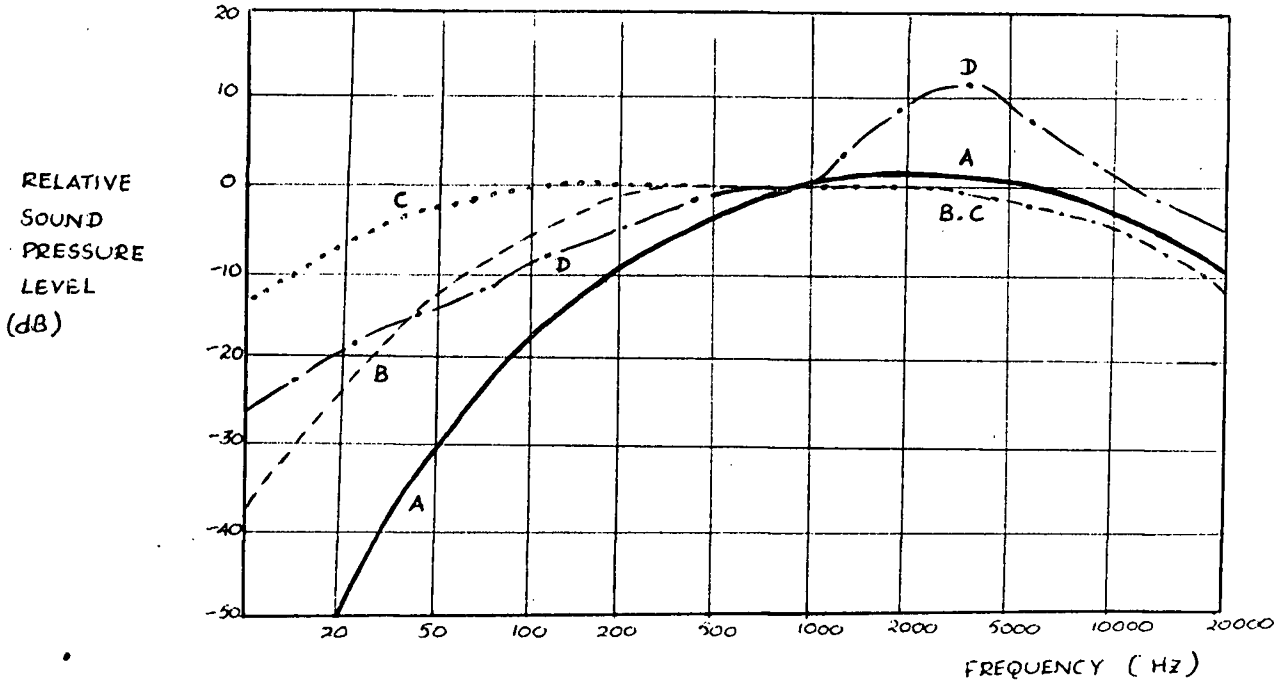

FIG. 10: GRAPHICAL REPRESENTATION OF THE SOUND WEIGHTING SCALES

(Source:"Noise in Industry"- C.I.S. Information Sheet No:17.1968)

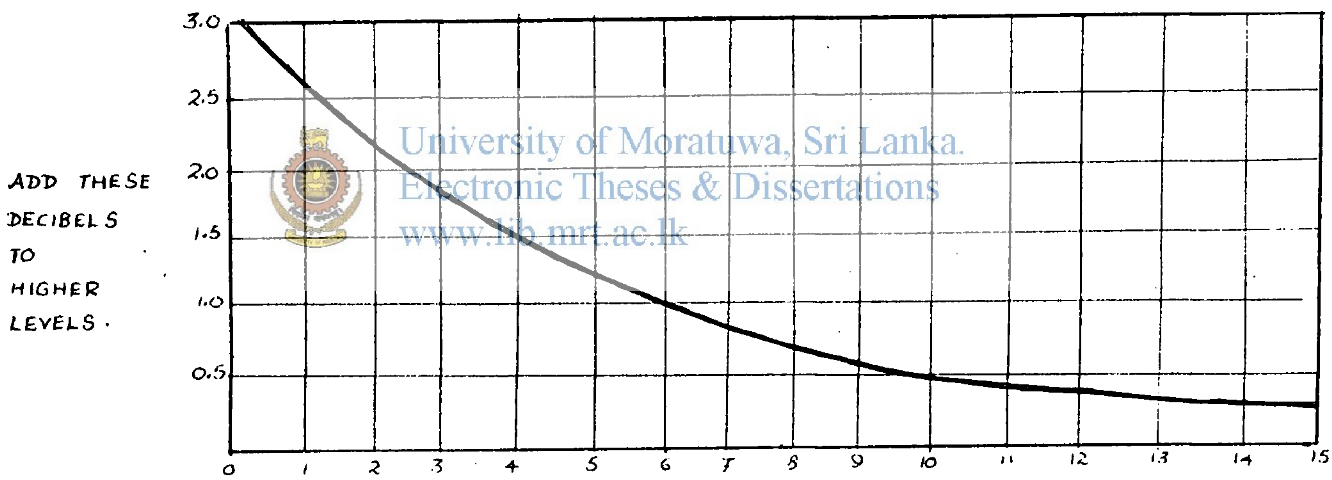

FIG. 11: CHART FOR ADDING DECIBELS

Examples: 55 + 61 = 62 dB

55 + 80 = 80 dB

60 + 60 = 63 dB

55 + 55 + 59 = 58 + 59 = 61.5 dB

(Source: "Noise in Industry"- C.I.S. Information Sheet No:17,1968)

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