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SYSTEMS NOISE IN BUILDINGS

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THE CONTROL OF PLANT ROOM NOISE

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INTRODUCTION. A considerable increase in the noise levels inside heating, ventilation and air conditioning plant rooms has come about in recent years through the growing popularity of air conditioning, and through the use of much noisier oil and high pressure gas burners on modern boilers.

The magnitude of the resultant problem is illustrated in Figure 1. Part (a) shows the sound pressure levels measured in the boiler house of a modern heating system and diagram (b) shows the range of sound pressures which occurred in ten plant rooms containing refrigeration compressors. For comparison the diagrams also show the sound pressure levels which would generally be considered satisfactory in a private office.

Bearing in mind the light construction of modern buildings, noises of the order illustrated must be most carefully controlled if the sound pressure levels in nearby occupied areas are to be kept down to acceptable values. This short paper is largely a review of practical measures which have been suggested for securing the necessary degree of control.

Plant Room Location and Construction. Ideally, plant rooms should not be located above or near sleeping quarters or rooms occupied by executives, or rooms used for conferences, board meetings and lectures. Where the plant room has to be near such critical areas, steps must be taken to contain the noise. The mass of the enclosing structure should be at least 90 pounds per square foot, which is equivalent to 9" brickwork or 7" of concrete. Where doors are not of the same mass, double doors may be provided or properly gasketted teak doors can be used. The value of gaskets deserves special mention. An ordinary closed door gives a noise reduction of 31dB in the 1200/2400 Hz band and 29dB in the 2400/4800 Hz band. These figures are increased to 39dB and 41dB respectively when the door is provided with gaskets. Windows ought to be avoided, but if necessary, double glazing should be employed, the air space between the two panes being at least 4".

All cracks, gaps or other openings through which sound could reach occupied areas should be sealed. A crack only 12" long and ¼" wide is enough to reduce the effectiveness of a partition, as regards sound attenuation, from 45 to 38 dB. Silencers may be necessary in the fresh air inlets and in the extract discharge openings.

Where plant rooms are immediately adjacent to an area where NC35 or less is specified it may be necessary to:
1)Provide a floating floor over the whole or part of the plant room area.
2)Suspend the sub-ceilings of rooms below the plant room with resilient hangers, and incorporate an acoustic barrier weighing at least 10 lb per square foot between the slab and the suspended ceiling with mastic seals between the barrier and the walls. The void should be at least 18" with all fittings, ducting and air diffusers below the barrier (see Fig 2).
3)Provide cushions of fibreglass or similar material at the head and base of plant room partition walls.
4)Alternatively provide special acoustic walls inside the structural walls.
5)Consider the provision of a concrete slabbed services void between the plant chamber and occupied rooms below.
6)Line all or part of the inside surfaces of the plant room with sound-absorbent material.
7)Enclose particularly noisy machines in specially designed "soundproof" boxes.

Plant Selection. For a plant room close to a critical area the engineering equipment should be selected for the output required but also with a view to reducing vibration and sound generation. When selecting centrifugal pumps the characteristic curve should rise continuously from maximum capacity to shut-off. The shut-off head ought not to be less than the design head plus 15%. The machines should operate at or near their points of maximum efficiency but should be capable of functioning at 25% more than their design capacity. The design impeller diameter is recommended to be less than x 90% of the maximum impeller diameter for the particular pump under consideration.

Fans should be chosen so that their operating points are at or close to the points of maximum efficiency. For high pressure fans the writer prefers centrifugal fans having backward curved blades of aerofoil section, because their high efficiency is usually associated with quietness of operation.

In the case of cooling towers it is advisable to obtain the maker's recommendations in each particular case after advising them of the relevant circumstances including the period of operation, the specified sound level in adjoining rooms and the nature of the external environment. The casings of all sheet metal ventilation and air-conditioning equipment should be properly stiffened to prevent drumming. For a plant room containing only fans or pumps their electric motors should be carefully selected from the machines on the market which have been specially designed for quiet operation. If there is any doubt as to whether their maintenance will be properly carried out it will be better to use an ordinary ball bearing machine having a frame size one above normal the engineer specifying that the ball bearings are to be specially selected for quietness. In general totally enclosed fan-cooled motors should be avoided. Motors should not run at more than 1450 rpm unless they have to be directly coupled to equipment requiring a higher speed of rotation.

Plant Connections. The connections between engineering equipment and building structure are obvious routes for transmission of sound and vibration.

Non-inflammable flexible connections should always be used to join suction and supply ducts to fans.

The final electrical connections to motors should be carried out in flexible conduit.

Flexible connectors should be provided at both the suction and discharge connections to reciprocating refrigeration compressors having remote evaporators or condensers. It is recommended that all reciprocating compressors be supplied with a muffler on the discharge. The writer has found it advisable to support the hot gas lines with hangers incorporating rubber-in-shear or spring isolators.

There is some difference of poinion as to the proper treatment of water pump connections. One method is simply to provide the pump with flexible connections on both suction and delivery. Alternatively, the piping is rigidly connected to the pump and supported each side for a distance of 40ft on resilient hangers.

Machine Mounting. Machine vibration can general intolerable noise in rooms both near the plant room and far from it.

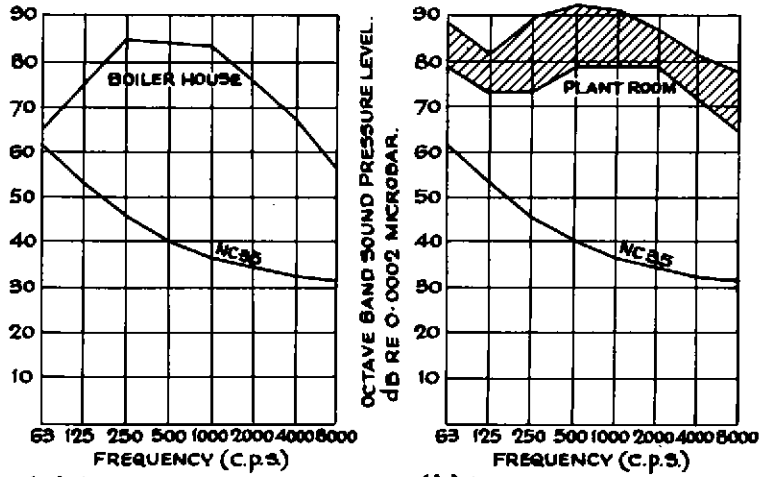
It is usually necessary to provide a mass barrier of concrete between a vibrating machine and the structural slab. The suggested ratios between inertia base and equipment masses range from 1:1 for fans, 1.5:1 for pumps and up to 8:1 for a large single cylinder horizontal air compressor. A simple rule for the thickness of the inertia base i 10% of the longest dimension in plant. Properly designed vibration isolators between the inertia base and the structural slab are essential in order to take care of the low disturbing frequencies. In the writer's opinion it is best to use proprietary isolators and get the manufacturer's recommendations for each particular application. It should be noted that for a given efficiency the deflection required does not depend solely upon the imposed frequency (arising from the machine) and the ratio of this to the natural frequency of the mount. It also depends upon (a) the flexibility of the structural slab and (b) the actual relationship between applied load and isolator deflection (this is often non-linear). In practical terms this means that the deflections actually required are frequently a good deal greater than those calculated from the classical formula. One author, for example, recommends the following deflections for a close-coupled centrifugal pump having a motor exceeding 7½ HP:

Basement below ground	0.75in
On ground (or above ground with floor span 20 ft or less)	1.00in
Above ground with a floor span of 40 ft	2.50in

In the writer's opinion caged spring mounts are the best all round isolators.

Summary. Broad measures for controlling plant room noise may be summarised as follows:

Locate the plant room away from quiet areas.
Make the plant room a heavy soundproof box.
Select quiet machines.
Use flexible plant connections.
Mount machines on vibration isolators.



(a) A MODERN BOILER HOUSE

(b) 10 TYPICAL REFRIGERATION PLANT ROOMS.

FIG. 1

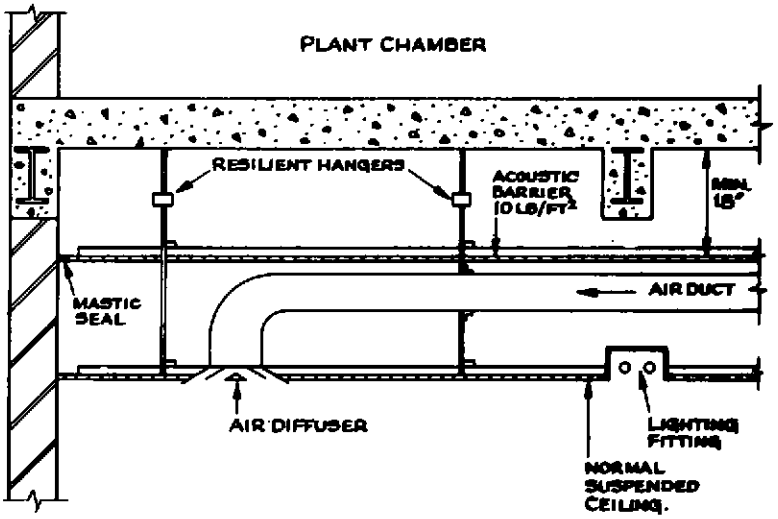


FIG. 2