THE THEORY OF VIBRATION ISOLATION

BACKGROUND

Soils, floors, cellings, walls etc. deflects as the result of applied forces. Cyclical forces generated by machines result in work done on the floors, etc. Under steady state conditions, this work is stored as potential energy in the floor each cycle and returned as work in forcing the machine back to its equilibrium position. Disturbance is transmitted during this flexing.

VIBRATION ISOLATION IS NEEDED WHEN DISTURBING FORCE MAGNITUDES ARE EXPECTED TO BE GREAT ENOUGH TO CAUSE DAMAGE OR ANNOYANCE.

ASSUMPTION	FACT
1. We know the effects of vibration isolation (effeciency)	Formula for calculation shown below.
2. We know the magnitude of the disturbing focers created by the machines.	Equipment manufacturers rarely provide these data. These forces are seldom known except in generalities.
3. We know the magnitude of disturbing forces beyond which damage or annoyance will result.	Detailed calculations require so many simplifying assumptions that the resulting answers have questionable value in addition to being prohibitively expensive. Reliance is placed on brief calculations, general rules and past experience

Consideration of items 2. and 3. is essential to deternine acceptable isolation efficiency. Unfortunately manifold complexities prevent inclusion of steps for determination of these efficiencies in this paper.

Natural frequency of isolation system f_n(cycles per minute)

Visualize a machine suspended barely above 4 springs (one at each corner). Now release the suspension. The machine will deflect the springs and be pushed up and return a number of times with dimishing deflection until it comes to rest. The spring deflection at rest is called the static deflection. The number of cicles per unit time is the natural frequency of the isolation system. Unlike multidegree of freedom floors with limitless natural frequencies, springs essentially have only one natural frequency.

$$f_n = 188 \sqrt{\frac{1}{\text{static deflection (inches)}}}$$

$$\text{Vibration isolation efficiency \%} = 100\,\% \times \left[1 - \frac{1}{(f_d/f_n)^2 - 1}\right]$$

Transmitted force F_t (pounds) $F_t = F_d$ (100 %-isolation efficiency)

Note that f_n must be small compared to f_d for satisfactory isolation efficiency. Also note that the force transmited can be greater than the disturbing force when f_n is close to or equals f_d . This condition is called resonance and is avoided in vibration isolation.

Natural frequency of floor or soil

Visualize the effect of dropping a load on a floor. The floor will deflect and spring back diminishingly a number of cycles until it comes to rest. The number of these cycles per unit time is a natural frequency of the floor. It is essentially independent of the magnitude of deflection and hence is a characteristic of a given floor if given a light tap or a hard joit at the same location. The floor has many natural frequencies. The lowest natural frequency is called the fundamental. It is characterized by maximum deflection at mid span. The higher natural frequencies are generally less bothersome than the fundamental since they are less likely to be excited by machines in common use and are more quickly damped. The greater a floor deflects under a given load, the lower the fundamental frequency of that floor. Soft, springy floors have low fundamentals. Hard, solid floors have high fundamentals.

Disturbing fequency f_d(cycles per minute)

With few exceptions, the speed (RPM) of the machine will be most representative of the frequency of the disturbance. Disturbances are most readily transmitted when the disturbing frequency is close to a natural frequency of the floor or soil. For this reason, these characteristics are important considerations in designing a trouble-free instalation.

Disturbing force F_d (pounds)

The disturbing force causes the problem. It is constantly changing from maximum positive through zero to maximum negative through zero to maximum positive each cycle. It results from unbalanced reciprocating and rotating masses. Its peak magnitude varies from ounces to tons. From less than 1 % to over 50 % of the weight of some types of machines. Generally this force will increase with time in a given machine as bearings wear, deposits form and moving parts get out of balance with each other.

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