

seems, can catapult microscopic charged grains of metal into the path of the electron beam, where they become trapped and do their mischief. The greater the beam current, the worse the problem.

What can be done, beyond the temporary expedient of switching to positrons? As the machine gets older and cleaner, Voss told us, the getter pumps will have less residual gas to contend with. Therefore, he explained, one might be able to run them at lower voltage, thus minimizing the danger of discharges. He and his colleagues are also experimenting with non-evaporable getter pumps. These new NEG pumps have porous metal surfaces that can absorb enormous quantities of gas.

NEG pumps are being used at LEP, the very large 50-on-50-GeV electron-positron collider at CERN. There are plans at CERN eventually to have longitudinally polarized electrons and positrons in LEP. But in a storage ring of such size and beam energy, depolarizing resonances are likely to be more troublesome than they were at HERA.

—BERTRAM SCHWARZSCHILD

References

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2. K. Abe *et al.*, SLAC preprint 6508 (1994), submitted to Phys. Rev. Letters. J. McCarthy, in Proc. 27th Int. Conf. on High Energy Phys., Glasgow, 1994, to be published.

IS THE NOISE OF OVERHEAD NEIGHBORS INESCAPABLE?

If you have ever lived in an apartment and had overhead neighbors, you have probably been annoyed by the noise they made just walking. This can be a problem even in luxury condominiums designed with acoustic privacy in mind. Now we know why.

A detailed study¹ of the problem by Warren Blazier Jr (president of Warren Blazier Associates Inc, of San Francisco, California) and Russell DuPree (Office of Noise Control, California Department of Health Services)

has revealed some startling facts about lightweight residential construction. Chief among these is that the peak energy in a footfall sound spectrum occurs at the fundamental natural frequency of the floor-ceiling system, typically between 15 and 35 Hz, not at the higher frequencies associated with, for example, clicking heels on a hardwood floor. Standard acoustic analyses of buildings, consistent with code requirements, ignore all frequencies below 100 Hz. The

lower limit of human hearing is frequently given as 16 Hz, but this varies with individuals. Furthermore it is less of a hard limit than a transition between sensing vibrations as aural effects and as tactile effects.

"What we're talking about here are the thuds and thumps of overhead foot traffic and their detection by the folks below," says Blazier, "who perceive it as noise." Adding carpeting or wearing cushioned track shoes may exacerbate the problem rather than alleviate it. "When you add such an element of resilience to the system, the rise time of the impact is

lengthened and more energy is coupled to the low frequencies," Blazier explains.

The usual methods for attenuating frequencies above 100 Hz—such as installing floating floors—simply don't work for these thuds and thumps. The most important ingredient turns out to be the structural factor kf_n , where f_n is the floor system's natural frequency and k is known as the static point stiffness of the floor system. Because the noise level depends logarithmically on the reciprocal of kf_n , only a significant increase in the floor's stiffness will help. For typical residential construction the following proportionality holds:

$$kf_n \propto \frac{(EI)^{1.5}}{w^{1/2} L^5}$$

where E is the modulus of elasticity (treated as constant), I is the moment of inertia of the structural system, w is the weight per unit length of the section used for computing I , and L is the length of span along the floor joist. For either wood or steel joist-framing systems, increasing I may require a significant increase in both the width and depth of the floor joists, while decreasing L implies adding more transverse framing. For economic reasons, however, builders are unlikely to pursue either of these options, because current building codes come nowhere close to requiring them. The practice of adding a poured concrete topping to the sub-floor doesn't help: The added mass lowers the natural frequency of the system slightly, and the two effects tend to offset each other. As a result the stiffness does not materially increase. On the other hand, the stiffness of residential construction that uses reinforced concrete for columns, beams and floor systems (as it often did 20 years ago, and still does in Europe) is at least an order of magnitude greater than the stiffness of wood or lightweight-steel joist construction; in such apartment buildings the amplitude of overhead low-frequency footfall noise is typically below the hearing threshold. Unfortunately for quiet-seekers, those reinforced-concrete residential buildings are a vanishing breed.

So what can apartment dwellers do about the bumps and thumps of the people upstairs? "Learn to live with it," advises Blazier.

—STEPHEN G. BENKA

Reference

1. W. E. Blazier Jr, R. B. DuPree, J. Acoust. Soc. Am. **96**, 1521 (1994). ■



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"Oh, hi! I'm Dwayne, your new upstairs neighbor!"