for control. Their individual readings should not vary excessively. We try to simulate a diffuse sound field, with sufficient evenly distributed modes to avoid large spatial frequency-based variations of sound pressure level within the test volume. The workers will of course vacate the room before the test commences.

Figure 23-26 suggests the overall facility layout for such tests. Intense noise tests are conducted in a reverberant (hard-walled) room, as in Figure 23-25. Note the microphones at various locations to (during the test) check the SPL. Their outputs are usually averaged for control. Their individual readings should not vary excessively. We try to simulate a diffuse sound field, with sufficient evenly distributed modes to avoid large spatial frequency-based variations of sound pressure level within the test volume. The workers will of course vacate the room before the test commences.

Sound is usually generated outside the chamber in the "throat" of a horn which smoothly increases in cross-sectional area, passing through (see Figure 23-27) the chamber wall. The "gas supply" can be pressurized gas storage vessels, liquid nitrogen vaporization systems or air compressors. Note the closed loop acoustic control, originally analog but now of course digital.

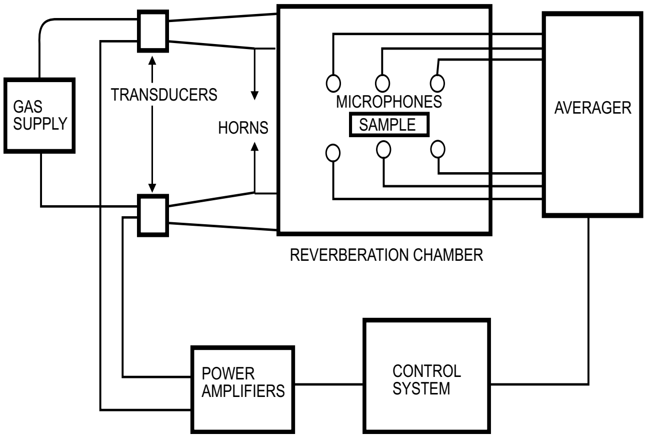

Figure 23-26 Sound is generated outside the chamber
(courtesy of JPL)

In Figure 23-27 the electropneumatic (see Figure 23-28) valve is just out of sight at the right. It modulates the gas (most commonly nitrogen) stream through the horn into the test chamber.

Figure 23-27 Horn passing through chamber wall
(courtesy JPL)

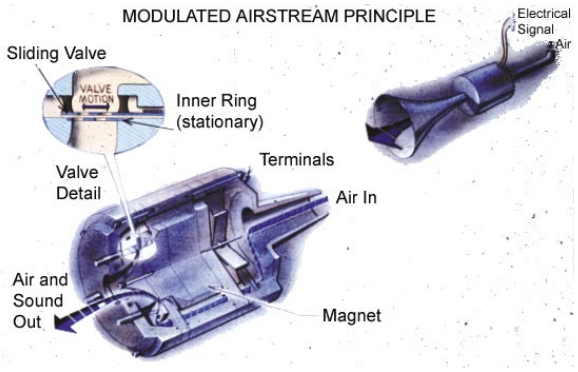

Figure 23-28 Construction of electropneumatic valve
(courtesy Ling Electronics)

An alternative approach (requiring higher supply pressure and producing higher sound pressure levels) involves an electrohydraulic actuator. To a degree, these resemble the valves controlling the electrohydraulic shakers of Chapter 13.

Pioneering work is this field used multiple sirens, fixed or "warbling" in frequency. Alternately, as many as 31 electrodynamic loudspeakers driven by say 40 kw of audio amplifier power have been pointed at hardware, achieving 135 dB overall SPL.

Figure 23-29 shows an above-the-chamber installation. Piped nitrogen gas feeds gas modulators, each feeding a single horn penetrating the chamber roof (instead of a wall). The multiple horns (different sizes for different parts of the spectrum) allow greater total power (in acoustic watts) and permit closer spectral control (in dB). Sometimes, instead, valve and horn are located *inside* the chamber, usually in an upper corner.

Figure 23-29 Generating through-the-ceiling high-intensity noise (courtesy of the Integration and Testing Laboratory, INPE, Brazil)

Figure 23-30, taken at another facility, shows a large piece of electronic hardware suspended in front of a horn and being subjected to intense noise pressures.

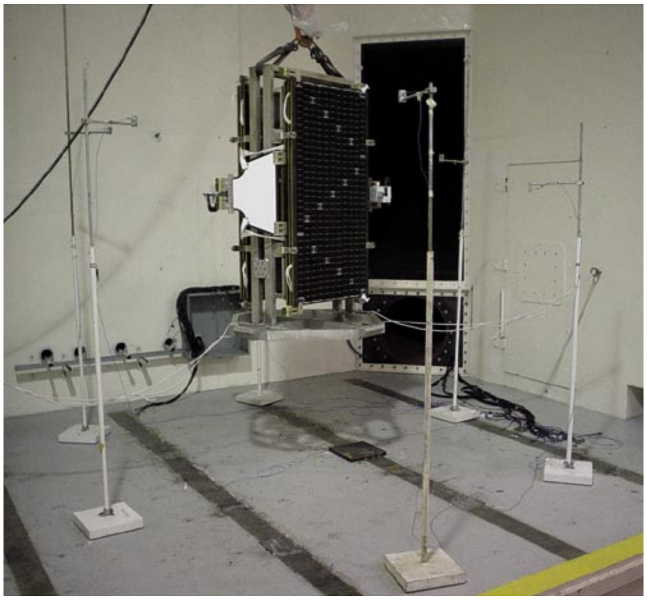

Figure 23-30 Acoustic testing in front of horn. (courtesy of NTS)

Much of the random excitation that produces vibratory responses in relatively thin elements such as printed wiring boards (PWBs) is coupled by air. Consider the fighter aircraft of Figure 23-31, shown here with access doors open. Turbulent in-flight airflow forces the skin to vibrate. That causes high-intensity sound inside the electronic compartments. That in turn excites PWB vibration. Hence acoustic, intense noise testing of electronic assemblies "makes sense".

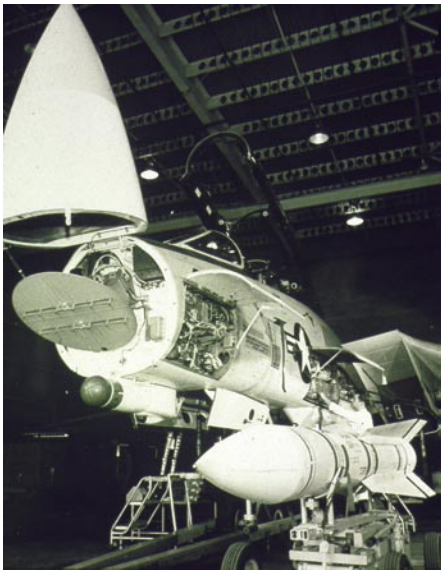

Figure 23-31
Much of the excitation affecting wiring boards is air-coupled

Or consider the long, slender externally-carried weapon of Figure 23-32. Again, turbulent in-flight airflow forces the skin to vibrate. That causes high-intensity sound inside the weapon. That in turn excites PWB vibration. Intense noise testing of the weapon would make more sense than exciting the weapon at two locations with two shakers.

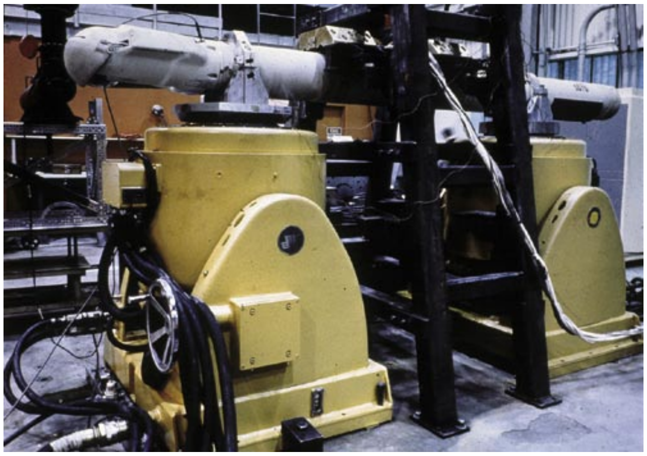

Figure 23-32 Only two shakers is not realistic

In Figure 23-33, we see three pairs of externally-carried missiles accumulating "flight time" during a combined-environment reliability test. They go through numerous simulated sorties from takeoff in the tropics (hot) to high altitude flight (cold), to simulated combat at varying altitudes, and return to the aircraft carrier. They are receiving not only

- thermal stressing (ducting in foreground to shrouds around guidance sections of each missile) but also

- low frequency random vibration from three electrohydraulic shakers and

- intense noise (generating high frequency internal responses) through the portal at rear.

This is cheaper, faster (24 hours/day) and safer than using jet fighters as test beds.

Figures 23-25 through 23-33 dealt with reverberant rooms. Sound energy is reflected by hard, reflective walls (usually painted concrete) to maximize sound pressure per acoustic watt generated. The sound should approximate a diffuse field, propagating equally in all directions. That is appropriate for simulating a time when hardware is not moving but receives severe noise. An example: simulating launch on the guidance portion of a ground-launched weapon.

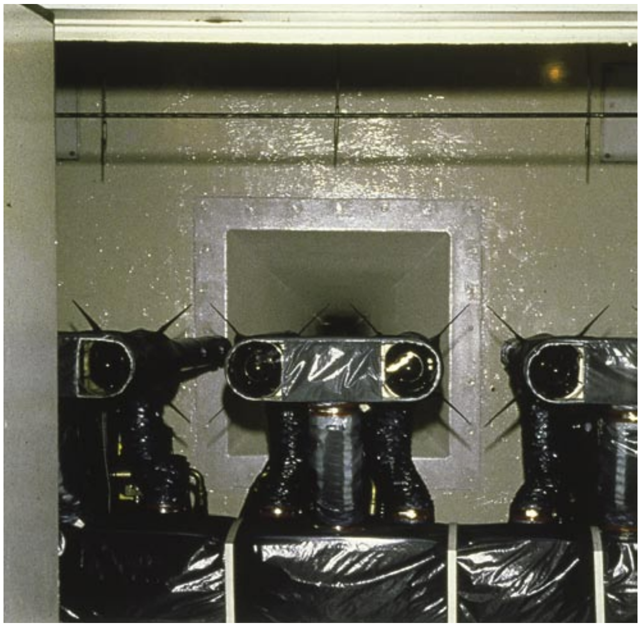

Figure 23-33 Six missiles receive combined environment testing (courtesy US Navy, Point Mugu, CA)

But for simulating some types of high velocity airflow in-flight noise effects on an airplane control surface, a progressive wave tube, such as those in Figures 23-34 and 23-35, is appropriate. In such a facility, sound energy flows against and past a structure under test.

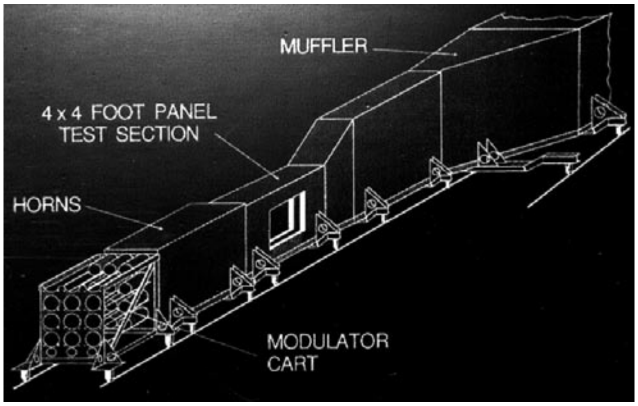

Figure 23-34 Concept of progressive wave acoustic test

Useful with either reverberant or progressive acoustic testing is the controller whose display is shown in Figure 23-36.

Figure 23-35 Progressive wave acoustic test
(courtesy NTS)

Figure 23-36 dB vs. frequency display
(courtesy Wyle)