

Chapter 6: Secure Facilities

Most of the acoustical design for normal offices deals with *accidental* listeners that have no interest in the conversations overheard. Unfortunately, there are many cases where the listener is a *deliberate* eavesdropper who may make use of sophisticated listening devices to improve speech intelligibility. Examples occur in government, military, and commercial situations. For deliberate listening, the normal methods of acoustical design are not adequate and new techniques and equipment must be utilized.

The reason for concern is that most major strategic and tactical decisions are first made orally at meetings and, if an eavesdropper can obtain access, it gives him a distinct time advantage over written or computer documents. Therefore speech is again the primary focus.

To protect conversations, it is normal practice to use the structural “solution”; rooms that have high sound attenuation. For example, the government uses the technique of a room-within-a-room that is very expensive. Unfortunately, many facilities do not have the budget for such measures, particularly when one considers all the ways audio access might be achieved. Worse yet, rooms with high sound attenuation do *not* guarantee protection. As with normal office design, there are three factors that play a role in protecting conversations: how loud the conversations are, how much those conversations are attenuated en route to a potential eavesdropping location, and how loud the background sound is at the eavesdropper. The technical weaknesses of rooms with only high sound attenuation are apparent. If a sound system is used to amplify speech (PA system, speaker phones), the room cannot be changed to accommodate the raised levels. When a room is constructed, there is no knowledge of the background sound level at locations where listening devices might be placed. A less obvious weakness is that modern listening devices can be placed in locations that building structure cannot protect against (inside wall cavities, remote sensors of window vibration).

Sound masking fills that gap; we call it *security masking* to differentiate it from normal sound masking methods. Not only does it permit the user to adjust and verify the degree of protection from most eavesdropping methods, but it also affords very large cost reductions in both room construction and security maintenance. As shown below, this method of protection is accepted and used by the federal government. In addition, masking systems can be installed permanently or used in temporary locations such as hotel meeting rooms. The goal for secure facilities is Secret Privacy.

Since most facilities are protected, CCR ASSOCIATES is involved with only security masking aspects and not facility design.

Applications

CCR ASSOCIATES has found there are a growing number of applications for secure masking. Any organization that has a need for protecting sensitive conversations from actual or potential

eavesdroppers should consider using sound masking as an effective deterrent. Organizations that benefit from such protection are:

- Department of State facilities, such as embassies
- Department of Defense facilities
- All military departments
- Department of Homeland Security agencies
- Narcotics agencies
- Intelligence and counter-espionage agencies
- Corporate research facilities
- Corporate planning facilities
- Corporate human resource departments
- Corporate mergers and acquisitions departments
- Corporate boardrooms
- Legal offices
- Accounting firms

Standards

There exist a number of regulations for protecting sensitive conversations, most are promulgated by the federal government. Examples of them are Defense Intelligence Agency Manual 50-3, Director of Central Intelligence Directive 6/9, Air Force Pamphlet 8-26, and the Gramm, Leach, Bliley Act that protects financial information. These regulations point to the important of protecting classified, sensitive and financial information.

Concepts of Security Masking

Categories of Surveillance

Two must be addressed. *Uncontrolled areas* are those where the persons attempting to protect themselves have little or no control over the environment. Generally, this includes all areas outside the building in which the secure room resides, such as parking lots or other public spaces where it is possible to gain access without detection. *Controlled areas* are those within a building where there is a measure of control. The method of protection depends on this difference.

Types of Masking Signals

Taking into account the capability of sophisticated listeners to recover speech buried in noise, it is necessary to provide *layered* protection. Instead of just one type of masking signal such as was discussed in earlier chapters, the generator creates and mixes several signals. For uncontrolled areas, *non-stationary* random noise must be the first layer. It covers the entire speech spectrum as in commercial sound masking, but its non-stationary characteristic inhibits signal recovery. For controlled areas, the less expensive stationary random noise generator is adequate. Music may be used as the second layer; it is buried below the random noise so it is not actually audible to room occupants. Voice babble or speech samples may be used as a third layer; it may be set at the same or lower level as the music signal. If equalized properly, the fourth layer, the actual voices to protect, will be sufficiently buried below the other layers.

Types of Masking Systems

There are two types of masking systems, the fixed and the portable. Most of this discussion will concern the fixed system permanently installed in the room to be secured. However, there are situations where sensitive conversations must be conducted while traveling, such as in hotel/motel rooms. The portable system can be used for this situation. It provides coverage of windows, doors, walls and air vents. Installation is quick; the maskers are attached temporarily and are removed when done. Evidence of attachment can be removed easily. This system does not have the refined capability of fixed system equipment, so levels are set higher than for fixed facilities in order to guarantee protection. As a practical control, all equipment and wiring should be contained within the secure room whenever possible.

Handling Amplified Speech

In some secure facilities, such as conference rooms, audio amplification of speech is used; it may be with a microphone or as part of a playback system. There are several aspects of such use that make eavesdropping simpler. These systems are almost always set too loud, and the level can be too easily adjusted with the turn of a knob. Protection of speech requires precise measurement, which can be completely undone with the turn of a knob. Worse yet, the adjustment of treble controls can enhance speech intelligibility just as is done with hearing aids and paging systems. To ensure that protection schemes are effective in protecting speech, audio systems should *not* be used. Unfortunately, some rooms, e.g., boardrooms, will have them. When this is the situation, physical controls need to be put on the equipment to limit the maximum level and the frequency spectrum. This requires modification of the equipment.

Locations for Protection

Consider the perimeter envelope of a room as a location for listening devices. Windows, walls, doors, ducting, piping, ceiling plenums, raised floor cavities, and loudspeakers are all penetration points. Each location is discussed in more detail below. First, the threat is addressed, then the standard solution, and finally the sound masking solution.

Protecting Windows

The Threat

Windows face uncontrolled areas so special measures need to be taken. A prerogative of high office has always been windows, both in offices and conference rooms. The word “eavesdropping” originated with listening at window eaves. It should go without saying that an open window is an open invitation to listening, so that aspect is not discussed. However, speech near a closed window causes a minute vibration of the pane that appropriate sensors can detect. Since windows respond well at speech frequencies, the window easily carries intelligible speech in the form of vibration. Figure 6-1 shows how strongly a voice can excite the vibration of a window, especially at frequencies where intelligibility is high (2000 to 4000 Hz). This was for a male talking at normal voice level at three feet and facing the window. Although the actual vibration levels are not large, any vibration detection device can recover them. It is clear from this figure that windows are ideal locations from which to detect conversations within a room.

There are three ways to eavesdrop. First is the direct attachment of a *vibration detector* on the window pane or the frame. Accelerometers or strain gauges are difficult to see, but can be discovered by inspection so are unlikely to be successful when attached. These devices are commonly available. Second is the *laser microphone*. The transmitter of this device sends an infrared beam that reflects from the window to a receiver. The minute vibrations of the window modulate the carrier frequency that is later demodulated into speech. Theoretically, such a device can operate from any distance and, since the beam is invisible, is a potent detection device. Since the beam undergoes nearly specular reflection, very careful positioning is essential, which is time consuming and reduces the number of microphone locations and the number of windows that can be covered. Although manufactured in Europe and the United States, ordinary citizens are not permitted such devices. The present widespread protection of windows in secure government facilities suggests that these devices are in common use. Further, many websites suggest designs for such devices. Random window vibration caused by high winds or high levels of traffic noise will act as masking and so will inhibit detection, but these factors are not under the control of the person attempting to protect the room. Third is the *highly directional microphone* that detects the velocity fluctuations of the window (the radiated sound). The advantage of this device is that it can be at relatively arbitrary angles to the window; the disadvantage is that the distance must be shorter than for the laser microphone. Not all such microphones have a large parabolic reflector that would make it easier to detect. These devices are commonly available, such as for sports events. Again window vibration caused by exterior noise sources will inhibit detection.

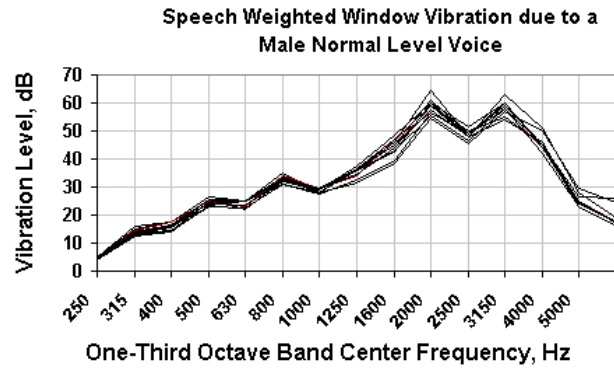


Figure 6-1

The Standard Solution

The most secure solution, and the one recommended by CCR ASSOCIATES, is to eliminate the windows entirely. Although it is the best solution, it is not always acceptable to occupants. Some have considered double pane windows with a higher STC rating as adequate protection; that is not so.

Since more than acoustic emissions occur through windows, films have been applied to block any electromagnetic emissions. There have been claims that such films will protect speech also. Unfortunately, a film will *not* sufficiently reduce the mechanical vibration of a window that carries the speech.

The Masking Solution

Early masking methods placed a loudspeaker facing down from the suspended ceiling. They were called *window washers* since the sound “washed” over the window causing random window vibrations. Unfortunately, the level required at the window was loud enough to interfere with the

speech to be protected, as well as to annoy the occupants. To converse, voices had to be raised, a self-defeating proposition.

The modern method is to attach a vibration masker to the window; it creates a broad band random vibration covering all speech frequencies. Because windows have many vibration modes, positioning of the masker is important.

Figure 6-2 shows a schematic of the masking effect. The window vibration blocks the laser microphone and any attached devices, and the radiated sound on the exterior of the building blocks the exterior directional microphone. Since the speech sound in the room decreases as it approaches the window and the vibration masking decreases as it moves away from the window, persons in the room do not have to speak louder than normal.

For masking purposes, CCR ASSOCIATES has defined groups of windows; each has to be treated differently. They are:

- Windows with the largest dimension less than five feet.
- Windows with the largest dimension greater than five feet.
- Windows with a number of smaller panes.
- Windows with double Panes.

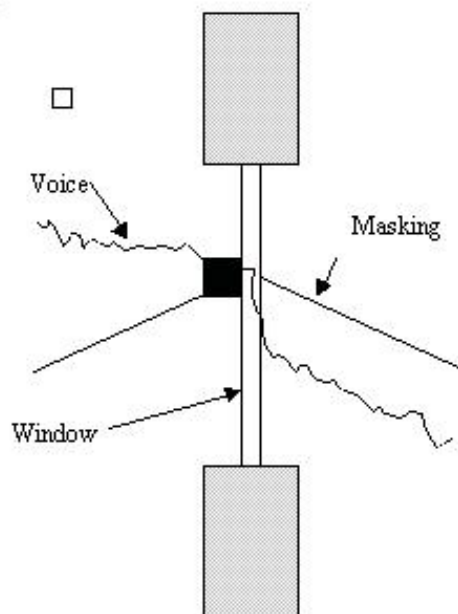


Figure 6-2

Protecting Walls

The Threat

Again, there are two categories of walls, exterior walls facing uncontrolled areas and interior walls facing controlled areas.

Exterior walls can be constructed of many materials, not all of which require protection. Because interior walls are most often constructed with studs and gypsum board to reduce weight, listening opportunities are better if access to the wall cavity can be achieved. For example, standard construction may consist of one or two sheets of gypsum board on either side of a wooden or metal stud with an air cavity that may, or may not, be filled with fiberglass. There are several ways speech can be detected through walls.

Remote from the wall. On all types of walls, listening can be done remotely from the far side, with microphone or ear. On exterior walls this method is greatly inhibited by the heavy wall structure and the fact that the outdoor background sound level is generally high enough to further inhibit eavesdropping. However, on interior walls, with much lighter construction, such is not the case as

persons in many closed offices can attest. This method of listening must be taken into account for both interior and exterior walls.

On the far side of the wall. Detection of wall vibration on the far surface can be accomplished with a remote laser microphone or by attachment of a vibration detector. On most, but not all, exterior walls, detection of this type is very difficult. On interior walls, with their lighter construction, vibration probes can be used quite effectively. This method of listening must be taken into account for both interior and exterior walls.

Within the wall cavity and on interior surfaces. Wall cavities can be hollow or filled with fiberglass for thermal insulation or for additional sound attenuation. Penetration of either exterior or interior walls having cavities can be used to place acoustical devices in the cavity as well as to attach vibration devices on either of the inner surfaces of the cavity. There are two acoustical devices that can be used within the cavity. The first is the normal microphone that converts sound to an electrical voltage. Many are quite small. They may require a wire to carry the signal out, or have a transmitter to send it remotely. The second is the less known *fiber optic microphone*. It is an analog to the laser microphone used on windows, except that the beam is confined to a fiber optic cable. It has no metallic parts except for a thin aluminum diaphragm. It is very difficult to detect, is quite small and may be mistaken for a normal fiber optic cable if merged with others. This method of listening must be taken into account for both interior and exterior walls.

How good is the acoustical environment in a wall cavity? A sound source was placed in a room. The speech weighted sound attenuation across the wall to an adjacent room was 41, a loss that would be considered acceptable. The speech weighted sound attenuation *into the wall cavity* was only 21, a considerable advantage for an eavesdropper. What about the background spectrum inside the wall? The level was about 15 dB lower than that in either room; an excellent listening environment.

The Standard Solution

The standard solution has been to require high Sound Transmission Class walls. Established methods die hard; federal standards require walls with STC ratings of at least 45. As with all structural solutions, one may ask the question: Is the sound attenuation adequate to create speech privacy? It is only adequate if the background level in the listening room is sufficiently high (See Chapter 4 on closed offices). It does not, and cannot address, the listening environment *inside the wall*. As a result, a high STC rated wall, although recommended, is not sufficient to solve the privacy problem. Fiberglass is often added to the wall cavity to enhance the STC rating. Unfortunately, it is only partially effective against listening devices beyond the wall, and is not effective for devices within or on the wall. Further, fiberglass inhibit the distribution of sound masking within the wall. Whenever possible, **fill the wall with sound, not fiberglass.**

The Masking Solution

An early masking solution was to place a loudspeaker masker inside the wall cavity; it was mounted on the secure side wall with an inspection plate. The cavity volume was filled with sound. The interior sound field vibrated both layers of gypsum board, the outer layer of which radiated

masking to adjacent rooms. Thus it covered *all* possible listening devices and locations. The sound level created by the masking did not create speech interference or annoyance within the secure room.

The current solution is to attach a masking vibrator to the wall on the secure side, as shown in Figure 6-3. This newer method has certain advantages. It is simpler to install and inspect, does not require penetration of the gypsum board, wiring can be seen and inspected, and is just as effective. If the vibrator meets building codes, it can be placed above the suspended ceiling. The sound masking is created by motion of the secure side wall, radiating sound into the cavity. The unsecure side wall vibrates in response to the cavity sound and reradiates masking beyond the wall. Thus, contact devices on either wall board are masked, the interior cavity is masked, and the unsecure side room is masked. As with windows, the voices in the secure room decrease as they approach the wall, but the sound masking decreases as it radiates away from the wall. The sound masking does not interfere with secure side conversations.

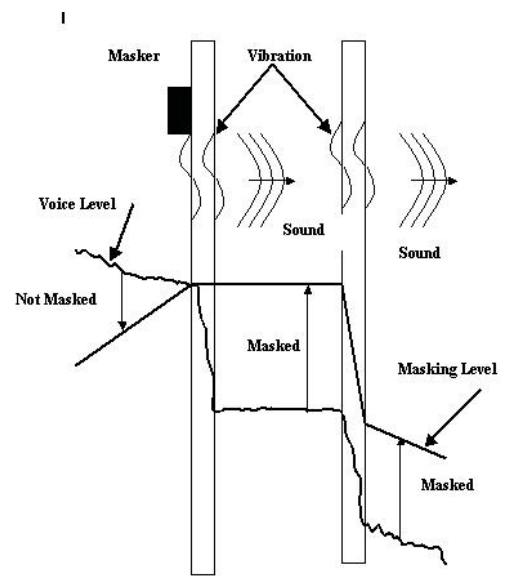


Figure 6-3

Protecting Doors

The Threat

Doors are weak links in walls. Typical doors may be hollow core, solid core, metal, or special. They can open to exterior uncontrolled areas, or to internal controlled areas. Every door has a gap around its periphery. These gaps may, or may not, have gaskets. Because carpeting is often used, the gap at the bottom is generally larger. Doors with built-in return air grilles are *never* acceptable. Because listening at a hollow core door results in clearly intelligible speech, such doors are *not* acceptable. Listening at a door gap, without a gasket, can result in intelligible speech at reasonable distances from the door. For interior doors, eavesdropping with the ear is the most likely surveillance method, although it is unlikely that a person will stand close for an extended period of time. It is also unlikely that detection devices will be attached to interior doors. This is not the case for doors opening to uncontrolled areas (e.g. emergency exits, or seldom used adjoining doors). Remote sensing of exterior door vibration or sound radiation are potential threats similar to that for windows. Listening with a vibration device, or directly, at an exterior door is possible but can be detected by inspection.

The Standard Solution

The standard solution is an architectural (structural) one where a hollow core door is replaced with a solid core door internally or with a metal door externally. To provide more protection, gaskets are added at the gaps and a *floor wiper* is placed at the bottom. Although these solutions improve

matters and are recommended, they have the same limitations as all sound attenuating mechanisms; they might not be enough. Avoidance of exterior doors is the best solution when permitted.

A more effective structural solution is to install doors with very high STC ratings. These doors are specially built to greatly improve sound attenuation. Unfortunately, they still are sound attenuating devices. They have several drawbacks. They are very heavy, much more difficult to install and are very expensive compared to normal doors. Further, the wall framing has to be altered to accept the thicker frame and that means adding more gypsum board to match.

The Masking Solution

A vibration masker is added to the secure side of a normal solid core interior door that has gaskets and a floor wiper. The door masker is the same as that used for walls. The door vibration radiates into the door gap as well as from the outer door surface. Vibration protection is provided on the door surface as well as beyond the door. As with wall masking, the sound radiated back into the secure room decreases with distance. As a result, conversations within the room are not impeded. The same concept applies to exterior doors which are most often metal. With sound masking, very high STC doors are not needed.

Protecting Air Ducts

The Threat

Listening through air ducts is a time honored source of eavesdropping since almost all rooms have supply ducts, either round or rectangular, metallic or fiberglass, that connect to a multiplicity of rooms. Local ducts are typically metallic with no sound absorbing materials and therefore are decent speaking tubes. Speech within a room is attenuated as it passes through the grille and duct bend, but after that the decay rate is quite small. Fiberglass ducts transmit much less speech so if there is more than 10 feet between openings they usually are not a concern. For listening purposes, a microphone is inserted into the duct. It is also possible to use a vibration detector placed on the duct wall near a room diffuser for listening purposes. Since the devices are on or within the duct, detection must be by visual inspection or by a search for wires. There are cases where the duct connects to uncontrolled areas where access is easier.

The Standard Solution

Duct mufflers have been the traditional method of solution. They were added at each point where the ducts penetrate the room perimeter. For many secure rooms, this implies a number of mufflers. They are expensive, bulky, and require an adequate plenum height to fit and because of their weight are difficult to install. The worst part is that they have the weaknesses of sound attenuating devices. How much attenuation is needed? Further, they add significant pressure drop to the air handling system which creates additional operating costs.

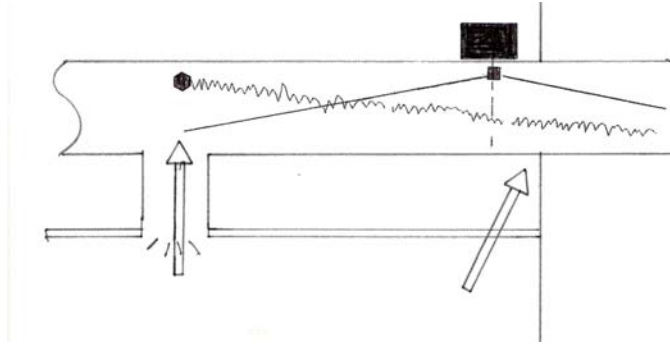


Figure 6-4

The Masking Solution

Speech that enters an air duct decays as it passes down the duct. Figure 6-4 shows a schematic of the two sound levels in the duct; one created by speech in the room and the other created by a vibration masker placed on the duct at the room perimeter. The sound attenuation of the masking into the secure room is so large that occupants are not aware of it. Similarly, the speech transmitted past the masker is completely buried in the masking, so privacy is assured.

Protecting Piping

The Threat

Normal liquid filled pipes do not carry significant speech energy nor does conduit piping filled with wires. Empty conduit pipes in secure room power panels are like speaking tubes on a ship. On some occasions, empty pipes passing through a room can carry some speech energy and should be protected.

The Standard Solution

One solution has been to place vibration breaks at the room perimeter for pipes passing through a room. Empty power panel conduits have rubber plugs inserted on the secure side; they provide adequate protection.

The Masking Solution

Masking is only required if an empty conduit is not plugged or specifications require protection on a liquid filled pipe. A vibration masker is attached to the pipe or conduit at the room perimeter.

Protecting Raised Floors

The Threat

In some facilities a raised access floor is used. Cabling or ventilation air may be supplied to the room under it. Both imply penetrations of the perimeter that must be protected. It is possible for *probe microphones* or *fiber-optic microphones* to be placed in the floor cavity, but because of the high sound attenuation of the floor they would have difficulty detecting speech unless an open grille is located on the floor nearby. *Vibration detectors* may be attached to the underside of a floor plate.

Since these plates are stiff enough to carry the floor load, they act more like a window in that they prefer to respond at speech frequencies, making such detectors effective.

The Standard Solution

If the threat is recognized, a wire mesh grid is placed over each perimeter opening. The only weakness of this solution is that alterations in the cabling often compromise the integrity of the mesh.

The Masking Solution

Loudspeaker maskers are placed under the floor; they serve two functions. Placing them near penetrations provides protection against listening devices there. Placing them uniformly under the floor, as is done in commercial facilities, provides speech privacy within the room itself as well as protection from any listening devices in the floor.

Protecting Plenum Ceilings

The Threat

Secure rooms often have a suspended ceiling with a plenum above to accommodate air ducts and cable runs. The walls defining the room may extend to the structural ceiling to create a closed plenum, or they may not to create a continuous open plenum. The plenum space is normally used for non-ducted return air. If the room has walls to the structural ceiling, there must be an opening in the wall above the ceiling to permit the air to return to the fan and it is normally not in view for inspection. Cable trays often penetrate the walls creating the same weakness. If the walls extend only to the suspended ceiling, the plenum is accessible to all other rooms. In each of the above situations, listening devices, such as microphones, can be placed in the plenum.

The Standard Solution

For return air penetrations in structure high walls, duct mufflers have been added. Again, they suffer the weaknesses of sound attenuating devices. Another exceedingly ineffective solution has been to lay fiberglass batts on the suspended ceiling. Cable trays have been either ignored or each cable has been individually sealed at the wall penetration, adding expense.

The Masking Solution

For structure high walls with a return air opening, a stub duct is added and a duct masker attached. For walls with cable tray penetrations, a loudspeaker masker is placed in the plenum just inside the opening. For open plenum spaces, loudspeaker maskers are distributed above the suspended ceiling throughout the secure room. One additional benefit, not normally contemplated, is that such masking provides speech privacy between individuals *within* the room. The levels within the room are set as with commercial facilities without compromising the protection afforded in the plenum.

Protecting Internal Loudspeakers

The Threat

Many building codes require the presence of speakers in a secure room for emergency announcements. Although speakers are intended for creating sound, the speaker also responds to external sound as a poor microphone. With proper detection, the voltage generated in the wire can be converted to speech.

The Standard Solution

An optical isolator is attached on the wire to the speaker inside the source room. It is an electrical diode; it permits a signal to go to the speaker, but prevents any signal to pass back from the speaker. This is the recommended solution; and such devices are commercially available.

The Masking Solution

If an optical isolator is not available, a masker can be placed next to the speaker. The required levels are sufficiently low as not to cause distraction within the secure room or interfere with the sound from the speaker.

Protecting Computer Keyboards

The Threat

A method has been developed to analyze the sound spectrum of computer keyboard strokes and thereby determine the characters that have been struck. Most modern keyboards are reasonably quiet, so sensing cannot be distant. Microphones embedded in local equipment, keyboard, or desk, mounted vibration detectors are potential sensing devices.

The Standard Solution

None is known.

Masking Solution

A vibration masker applied to the underside of the keyboard, with the proper spectrum, masks all spectral components of the keystrokes both with regard to keyboard vibration or the sound radiated. The user is not disturbed by the low level of the masking.

Special Generators Required

Stationary Random Noise

Generators that create this type of random noise are commonly available commercially and are used for normal sound masking systems. Special signal processing methods make use of the unchanging statistics of the noise to eliminate it and so recover an speech buried in it. These generators are less expensive and are used in controlled areas where the likelihood of signal processing is remote.

Non-Stationary Random Noise

These generators create a masking signal that changes its statistical characteristics from second-to-second to inhibit recovery of speech buried in the masking. These generators are more expensive and are used in uncontrolled areas where the use of signal processing is likely.

Special Speakers Required

Loudspeaker Maskers

These maskers are used in commercial applications. Their application to secure facilities is for ceiling plenum masking, under floor masking, or as window/wall washers. No modifications to them are required for these applications.

Vibration Maskers

These maskers are attached to surfaces and vibrate the surface to which they are attached. An example of the vibration masker that is attached to windows, doors, walls, or rectangular ducts, is shown in Figure 6-5. It is relatively small and neutrally colored to minimize visibility on windows.



Figure 6-5