Technical Features − Sound Construction
Design Aid For Office Acoustics

HOW TO DETERMINE COMPOSITE SOUND−ISOLATION RATINGS FOR OFFICES BY COMBINING PERFORMANCE OF WALLS, CEILINGS AND FLOORS

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The technology of sound isolation is highly complex, and pitfalls await the designer attempting to deal with it. Designers must consider background noise levels, flanking sound paths, the combination of materials in each assembly, the combination of systems in the space and even the profile of the sounds to be attenuated. Especially confusing is the process for determining how various components—floor, ceiling, partitions, wall openings, etc—work together to meet a given sound−isolation criterion for the composite construction. Such confusion can lead the designer to specify systems that cannot possibly provide the desired overall acoustical environment.

Specifying the same rating for the floor, ceiling and wall is rarely the best solution. In fact, there is no one "right" combination, as many factors must be included in the equation when components are selected. Also, in areas where the profile of the sound to be attenuated is different from that of speech, such as sound from mechanical equipment, it is risky for anyone but an experienced acoustician to recommend sound insulation constructions. However, it is not necessary to be an acoustician to competently select components that meet criteria for the room−to−room speech privacy normally required for office−type structures. The tables in this article combine acoustical data from a wide variety of sources to help you evaluate and select combinations of systems to provide a desired overall STC (Sound Transmission Class) rating for adjoining office spaces.
This article also provides current information about sound criteria, rating systems, limitations imposed by flanking constructions, effect of doors, windows and other openings in walls, etc., to help you use the tables confidently and correctly. With a reasonable understanding of construction and knowledge about specific products, you can use the data presented here to select wall, ceiling and floor constructions that will provide a composite STC rating within tolerable limits of accuracy. Note, however, that actual "as built" performance will almost always be somewhat better or worse than the calculated STC rating because each component in a construction is seldom identical to that used in the wall, ceiling, etc., tested in the laboratory. Also, acoustic data varies to some extent from one laboratory to another, and it is not possible to put absolute numbers on sound−flanking paths because of the inherent varieties of situations that occur in normal construction.

Assumptions and acoustical design criteria Normally, acoustical design criteria for a particular project should be established by the architect and/or acoustical consultant. If there is no acoustical consultant involved in an office project and the specifier lacks a thorough understanding of acoustic design, the criteria for sound insulation between spaces may be incorrectly stated or not stated at all. For example, sound insulation between offices may be incorrectly specified as a range, such as STC 40−44. The architect or other specifier needs to recognize that an STC 40−44 can only be interpreted to mean minimum STC−40. Ironically, STC 40−44 also suggests that anything above 44 is acoustically undesirable or even unacceptable.

In this article we will deal only with the insulation of airborne1 sound between spaces which are horizontally adjacent; not above or below one another. It is assumed that the sources of sound are the human voice and modest−size office equipment such as typewriters, duplicating machines, telephones, etc.

Remember that the STC system is based on the sound source having the frequency spectrum or sound profile produced by the human voice. Fig. 1 on page 9 shows that the STC system only considers frequencies from 125 Hz to 4000 Hz (hertz), the same basic range as speech. Therefore, the STC system is almost meaningless whenever broad−band (wide−frequency−range) sources such as machinery, music or exterior noises are involved. Note that music and mechanical equipment sounds extend down the full low−frequency hearing range to about 20 Hz, some three octaves below what is considered in determining an STC rating. Thinking of STC as "Speech Transmission Class" will help you avoid misusing the STC system.

Table 1 suggests STC criteria for various office areas, and can be used as a guide for choosing appropriate criteria for sound insulation between adjacent office spaces. Note the direct relationship between background noise levels

1 Airborne sound may be speech or the click of a typewriter, while structure−borne sound is that from vibrating equipment in direct contact with the building.

(RC2) and sound insulation (STC) requirements. Most office air−handling systems will provide a background masking noise (that decreases speech intelligibility) in the RC−25 to RC−35 range. Fig. 2 shows RC background noise level curves in 10 dB (decibel) increments. Fig. 3 illustrates the combinations of background noise and STC rating of office separation needed to provide speech privacy in the 0−10% sentence−intelligibility 3 range.

Most acousticians use RC−30 as a reasonable average for design calculations when the background masking noise is from an air−handling system. A background level of RC−35 can be assumed for private offices with personal computers.

Depending on background noise masking and office type, the typical composite sound−insulation criterion for closed−plan offices falls between STC−35 and STC−50. Since privacy requirements for closed−plan offices are usually stated in terms of STC ratings, the STC data for the systems that comprise the offices are also adequate for calculating the STC rating for the composite office construction.

STC Ratings Of Wails Containing Doors Or Windows

Many office walls are composite constructions in that they contain doors and/or windows (glazing). It is necessary to know the STC rating of the composite wall before the performance of the composite wall/floor/ceiling can be determined. This information also facilitates the selection of the most economical door/window/wall combination that will provide the required rating for the composite wall.

STC ratings for walls containing doors or windows are listed in Tables 2 and 3 for most combinations occurring in offices. Table 2 is calculated on the basis of a 3x7−ft. door or window occupying 21% of the composite wall area (21 sq. ft. of door or window per 100 sq. ft. of wall) and Table 3 is based on 33%. When the worst−performing component occupies greater than about 50% of the total wall area, for all practical purposes, the STC rating of the composite wall will be the same as that for the worst−performing component.

2 Note that RC (Room Criteria) ratings for background noise have replaced NC (Noise Criteria) ratings, but the two rating systems are numerically interchangeable.
3Note that the lower sentence intelligibility is, the less disturbing speech is to other people in an office.

Composite STC Ratings Of Office Components And Systems

Data on ceiling systems, partitions, glazing and doors is necessary to select a combination that will provide the desired composite rating. Tables 4−7 list a sampling of these components and systems with their STC ratings or ranges. After determining the ratings of the partition, door and glazing, you must then determine the composite partition rating (based on the area occupied by the door and/or glazing) using Table 2 or 3. Next, refer to the three graphs in Fig. 4. These graphs plot composite STC ratings for the entire office based on three different floor thicknesses compared to the STC ratings of the composite partition and ceiling system.

The three graphs are based on the floor, ceiling and separating wall areas being approximately equal in area. However, the wall area to floor area ratio can fall somewhere in the 0.66 to 1.5 range without significantly affecting the accuracy of the calculation. Most floor−to−wall−area ratios will be near 1.0. It also is assumed that the sound−flanking limitations described in Figs. 5 and 6 on page 14 and Tables 8 and 9 on page 13 are not present.

Sound−Flanking Considerations

Sound transmission loss measurements of a partition or ceiling system are made in the laboratory to determine the acoustical limitation of that particular construction system. The system is installed so that sound transmission via other building elements is virtually eliminated. For example, a ceiling system is measured utilizing a wall with far greater sound attenuation potential than the ceiling system. A test partition is at least 10 dB weaker than any other sound path between the two test rooms. Thus sound−flanking paths are not present to any significant extent. There are no interconnecting air ducts, conduits, flanking sidewalls or floors, openings, etc.

Measurements made with sound−flanking paths present usually have limited value for design purposes because they are only valid for the specific construction measured. It is usually more helpful to know the limitations imposed by flanking paths, and to exercise judgement to accurately predict the STC of composite constructions which have significant sound−flanking paths.

Many of the problems associated with sound−flanking paths, such as unpredictable acoustic performance, can be minimized by avoiding marginal or overly complicated details, or details that require fastidious field inspection in order to assure predicted acoustical performance.

It is important to recognize flanking paths commonly found in office construction and to know the approximate upper STC limits which these paths impose regardless of what floor/wall/ceiling system is used. The designer has no choice but to change a construction detail if the detail limits performance below the required design criteria.

It is difficult to quantify the effects on the STC of a composite construction that certain construction details have. However, the limitations shown in Figs. 5 and 6 and Tables 8 and 9 should serve as a reasonable guide. The STC's listed should be considered the maximum attainable with the detail shown unless an acoustician reviews the details of a specific project and recommends otherwise. Fig. 5 illustrates the STC limitations imposed on six typical composite constructions by flanking walls and windows. Fig. 6 illustrates the flanking limitations for three different arrangements of electrical boxes in partitions.

Cracks often occur where an office partition meets the outside wall, especially at a window mullion or at the glass without a mullion. Cracks can also be a problem at wall/ceiling and wall/floor intersections. Openings can occur when continuous fin−tube radiation or other continuous mechanical system is used on an outside wall. Cracks and openings have a profound acoustical impact.

Table 8 shows that an STC−20 is about the maximum rating possible for a wall with a total of 144 sq. in. of openings per 100 sq. ft. of wall. Also, note that cracks have a significantly greater effect on performance as the rating increases. For example, a 1−sq. in. opening reduces the performance of an STC−35 partition to STC−34; but reduces the performance of an STC−60 wall to STC−41! While it is not possible to accurately predict the area of cracks that might occur in a poorly constructed wall, the table clearly illustrates the magnitude of the problem and the penalties that such openings will bring. Thus it can help in determining the degree of care needed to assure that the required wall rating will be achieved in the field installation.

It is virtually impossible to apply a meaningful correction factor for the effects of electrical boxes in partitions and none is recommended here. The three arrangements shown in Fig. 6 are included as a design guide. Back−to−back or side−to−side outlets or switches (Fig. 6a) generally should be avoided in any partition when sound insulation is a consideration. Even well−caulked outlets within the same stud cavity should not be used in partitions rated over STC−40. The offset arrangement shown in Fig. 6b usually will be satisfactory in partitions rated up to about STC−50, assuming the boxes are back−sealed and caulked in place. The arrangement shown in Fig. 6c usually will be satisfactory in partitions rated up to about STC−60. Electrical boxes should be avoided in walls rated above STC−60 unless an acoustician works out details to suit the specific case.

The STC limitations imposed on composite constructions by various duct configurations or arrangements given in Table 9 on page 13 generally indicate what systems should be avoided if the imposed limitations are within a few points of the required sound insulation. The actual STC ratings will vary with duct size, duct system configuration and other factors that can even vary from room to room in the same office building. If it is necessary to utilize a duct layout that may provide a sound flanking path close to the sound−insulation criterion, an acoustician should make the necessary calculations and final judgment on the specific situation.

The information presented in this article was based on a more technical report on acoustics prepared by the U. S. Gypsum Architectural and Construction Services Dept. A copy of that report and/or complete information on U. S. Gypsum sound−control partitions and ceilings may be obtained by writing to Editor, FORM FUNCTION, 101 5. Wacker Dr., Chicago, IL 60606−4385.