- General Guidelines –

Soundproof Doors

Doors (and windows) are by far one of the the most common reasons for noise leakage within an enclosed enviroment. Since soundproofing up to an extent depends on the weakest link within a given enclosure, and keeping in mind that low-frequency soundwaves are able to make U-bends around corners, doors leading to a room where effective soundproofing is desired are a critical issue, and must be given primary importance.

Since doors cannot be fitted with internally spring- or shock-mounted faces due to the nature of their design, size and operation ergonomics, there is no proper substitute for sheer mass in a good soundproof door. Dense materials in this case are the only thing that will stop sound travelling through a door, even if the actual door provides a proper seal. For this reason, soundproof door leaves weigh a minimum of 85-90 kgs, and can be as heavy as 150 kg.

The performance of a soundproof door is dependant on four factors:

- Leaf Design
- Aperture Frame Design
- Gasket Seals and Hinges
- Installation

Leaf Design

The door leaf is the part which opens and closes within a complete door structure. Most entry-level soundproof door leaves use a technology called **Constrained Layer Mass Damping**. This employs different materials of different densities layered over eachother in a manner that addresses the reduction of vibrations, where the particular sequence and applied thicknesses of the successive material layers is important.

- Leaf Frame

The door leaf constitutes a frame all around its edge, made of rails and stiles. The three horizontal portions of the frame at the top, centre and bottom are called rails, and the two vertical portions of the frame on either side are the stiles. The frame consituting a soundproof door leaf is subject to three important considerations:

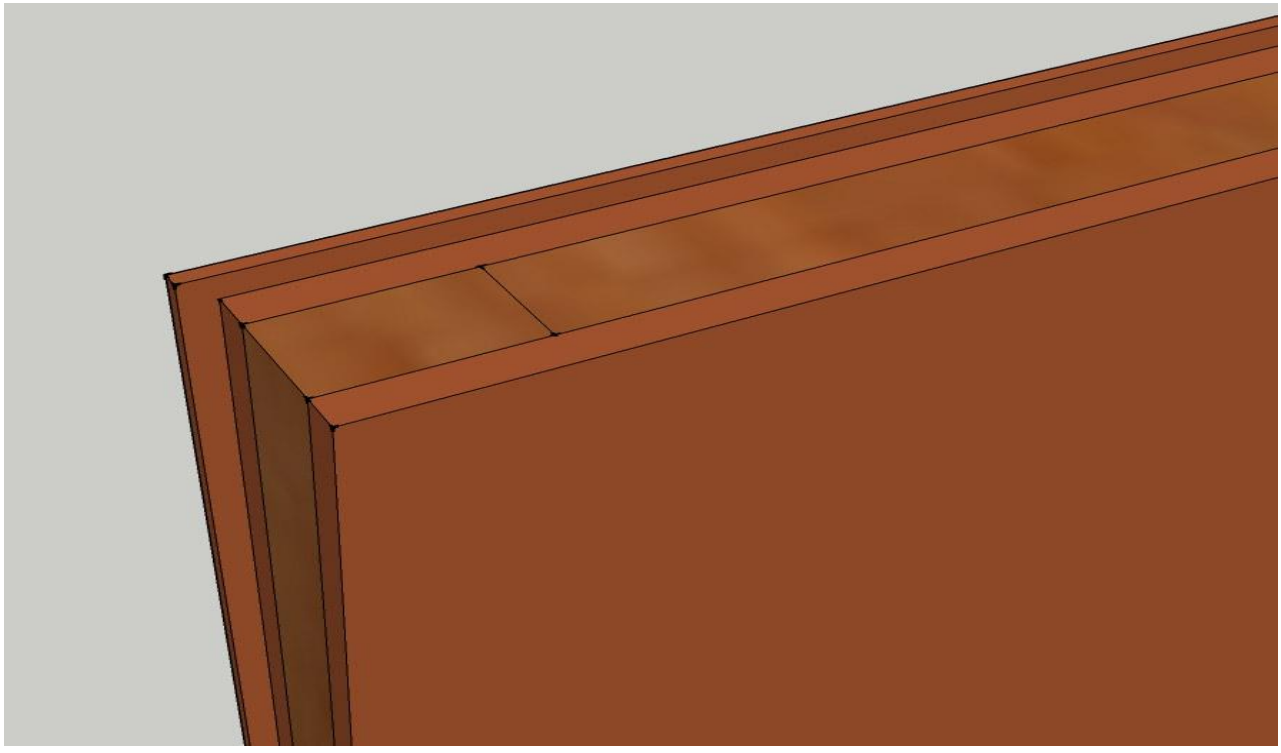
1 – It must be strong in compression tension and sheer, and be as little susceptible to splitting or warping under weight as possible.

2 – Materials used must be very dense in order for them to conribute to the sound barrier.

3 – It must expand and contract minimally under conditions of variable temperature and humidity, in order to avoid significant weather warping, which upsets proper seating against the seals on closure.

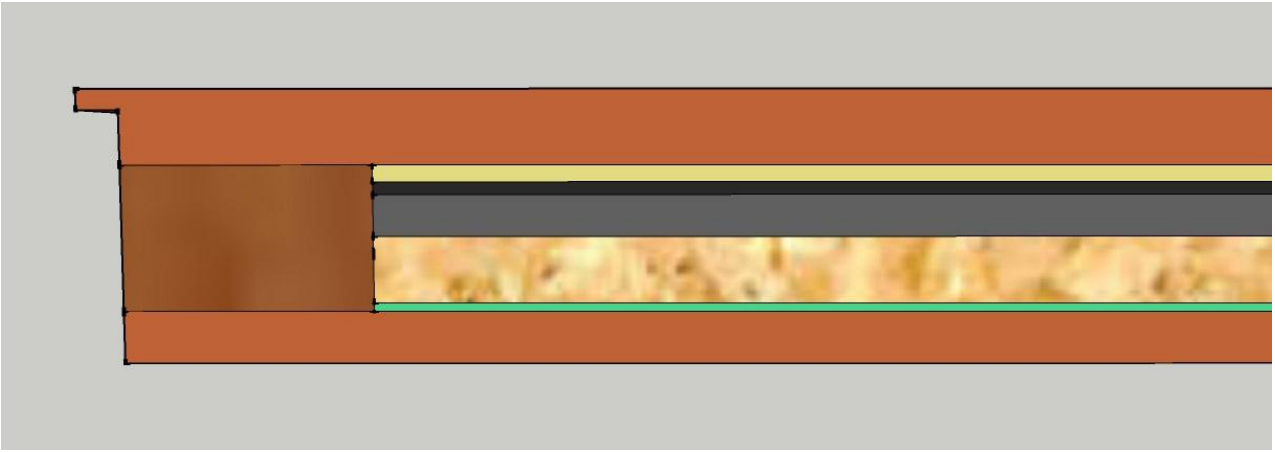
In wooden doors, the preferred material for the frame is therefore a well dried and aged coniferous hardwood. The hardwood provides the strength and the density, and the drying and ageing makes it less susceptible to expansion and contraction. A most commonly used wood in the manufacture of soundproof door frames is aged oak. Metal doors employ steel frames

The outer faces on both sides of “wooden” doors are usually made of MDF or HDF, and in metal doors the outer face is sheet steel. Importantly, one sheet is always thicker than the other in order to avoid the two boards having the same resonant frequency. The thicker (front-facing) board has an outward- protruding lip running around the edge of the door leaf. This lip is known as a **rebate**, and significantly makess the passage of air between the door leaf and the aperture frame more difficult. Use of a full rebate is only possible with single-leaf doors.



Soundproof door leaf showing a wooden door internal frame, front and rear HDF faces, and rebate machined out of the front HDF face

For entry-level soundproof doors, the thinner of the two outer faces is usually glued to a sheet of **high density Baltic Birch plywood** using **acoustic glue**. The acoustic glue dries into an elastometer which greatly improves sound-transmission loss between these two surfaces. Adjacent to the plywood is a **mass-loaded elastometer sheet** held in-between a sheet of **high density acoustic foam** and a sheet of **soundboard** or **acousti-board -** (These are rigit sheets of highly-compressed mineral fibre weighing c 4kg/m²). The soundboard / acousti-board sheet is in contact with the thicker of the two HDF faces, and the acoustic foam is slightly compressed when the materials are sandwiched together into a completed door leaf.



Soundproof door leaf - horizontal cross-section

Higher specification doors use solid wood slats in between rails and styles (industry standard is American oak), weighted elastometer sheets and HDF.

Aperture Frame Design

The aperture frame is the fixed frame lining the wall aperture over which the door leaf closes. Since door frames are significantly deeper than door leaves, and the surface area of the frame is too small to feature appreciable expansion in critical directions, in wooden doors there are much less rigorous requirements for the use of hard materials.

Some soundproof doors employ an aperture frame fixed to three sides of the aperture (excluding the floor). In this case the door leaf employs one or more **drop-seals** which lower a weighted neoprene-lined strip to the floor when the door is closed, in order to seal off the air-gap between the bottom of the door and the floor.

Other doors employ a system known as **full-lock** or **threshold**. Here the aperture frame surrounds the whole perimiter of the door leaf by including a floor threshold, and the door is therefore able to form a hermatic seal against rubber gaskets all the way round its edge.

** It is to be noted that if very high spec soundproofing is required, nothing beats a full-lock soundproof door. (Full-lock applies only to single-leaf doors). Full lock doors are commonly used in technical areas, service areas and AV studios, but are less practical in other circumstances because of the threshold.

Gasket Seals

Soundproof doors installed in the interior of a building usually employ two gasket seals, one installed to seal against the door-leaf rebate, and the other against the outer frame.

Although various types of rubber are used in the manufacture of rubber seals, (Namely *Chloroprene Rubber, PVC Nitrile, TPM, EPDM* and *plasticised PVC*), *Neoprene* rubber is preferred type of material employed in the seals of soundproof doors. Neoprene is flame retardant, has good weathering resistance, and is also resistant to acidrain and most solvents. The constituency of this elastometer provides an excellent acoustic seal and resistance to vibration (impact noise), and it is widely used in all soundproofing applications.

Soundproof door frame with threshold

Soundproof door with retracted drop-seal

Hinges

Soundproof door hinges are high spec metal alloy or treated stainless steel as they need to carry the weight of the door leaf. Once the door frame is set and the door leaf is installed, the hinges (and the drop-seals) need to be accurately adjusted, and this requires time, meaning installation for a soundproof door takes considerably longer than that required for a standard door. The hinges can be adjusted in 3 planes – two

planes (left/right/up/down) in order to align the door exactly to the gaskets and the third plane (in/out) to set the closing pressure against the same gaskets. The hinges are always external as setting must be carried out with the door closed. Soundproof doors with concealed hinges do not exist.

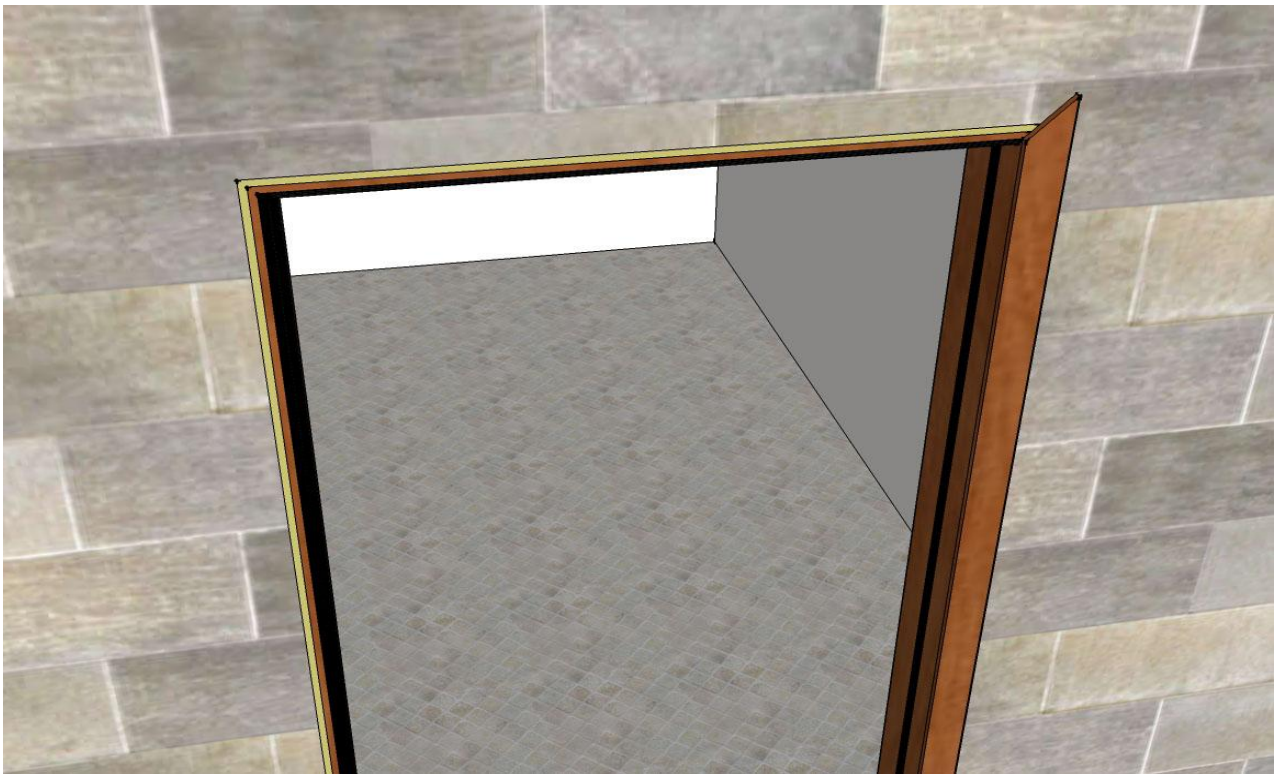
Typical 3-way leaf adjusting hinge for soundproof doors

Installation

Since soundproof doors are required to provide a hermetic seal between two areas, installation is critical because it needs to guarantee this requirement. Under the circumstances, the installers are responsible not only for ensuring close-to-zero air-leak between the apertrure frame and the aperture (wall or partition) when the installation is finished, but also a proper soundproof seal. If there is as much as a pinhole or a weak soundproof seal between the aperture frame and aperture, the installation will fail and the door performance will be considerably degraded.
The aperture frame must not be in contact with the aperture at any point in order to protect the door structure against impact noise. Full-lock door apertures are installed with acoustic rubber sheeting between the threshold and the floor, and the two edges of the threshold are sealed with acoustic mastic. The rest of the frame requires 1cm of space all the way round.

Some frames are screwed to the wall with recommended screw tensions provided by the manufacturer, in order to avoid warping of the frame. All the screw tensions must be the same. Following fixation of the aperture, the whole gap (one side to the other throughout its depth) is filled with expandible foam. Expandible foam has excellent acoustic absorbtion properties and provides a proper air-tight seal right through the thickness of the frame to the outside. Moreover, it does not deteriorate over time. Other frames employ only expandible foam without lateral fixations.

Finally the jambs are fitted and sealed all the way round with acoustic mastic, where the edges are in contact with the wall or partition.



Installed aperture frame showing expandible foam sealing the gap between the aperture and the wall, and the right-hand jamb

Fitting Soundproof Doors

In order to determine the specifications required for a soundproof door in any particular application, the noise levels within the particular room must be either measured directly, or in the case of new buildings where only plans are available, a virtual simulation is required. Following either of these two methods, the correct door to address the issue is selected.

Soundproof door specifications range from around 32dB up to 56dB per door. Door leaf thicknesses vary between c 55mm to 95mm, depending on the required door specifications.

Ratings up to 42dB can be achieved by using wood or metal doors. Ratings higher than 42dB require the use of a metal door.

Ratings higher than 56 dB can also be attained by installing two lower spec doors in series with a suitable gap in between them. The larger the space between the two doors, the better will be the performance rating. This is because when one door vibrates, it tends to compress the air in the sealed space between the two doors, and transmit the vibration to the other door. The smaller the volume of air, the more compression will be applied, and therefore the higher the pressure (vibration) transmitted to the second door.

Double-leaf doors always have lower specifications than single-leaf doors because of the central closure-seam between the two door-leaves, which invariably weakens soundproofing performance.

Fire-rated soundproof doors are available. Wooden doors offer ratings between 30 and 60 min, and understandably, metal doors have higher specifications. It is to be noted that wooden doors with 60 min ratings effectively replace some of the internal acoustic materials with fire-rated materials, and therefore do not have soundproofing specifications which are as high as doors with lower ratings, such as 30 min.

Soundproof doors, alongside fire doors and medical doors, fall under the subset of “technical doors”. Technical doors give less importance to visual design and are mostly available as flush doors,

All soundproof doors are tested in a laboratory and required to be certified by means of a test certificate in document form. Most doors carry certification plates attached to the edge of the door leaf on the side of the hinges.

Because of the precise material combination engineering, precision manufacture required, (including precision tight-fit of the door leaf to the aperture frame), necessary certification and critical installation to support such certification, soundproof doors are usually purchased as ready-made and factory-tested units from a reputable manufacturer or distributor, and installed by trained and certified personnel.