- General Guidelines -

Soundproof Windows and Framed Glass Doors

Before attempting to understand the ergonomics of specified soundproof windows and framed glass doors, it is necessary to diversify between specifications for standard frames and specifications for specified soundproof frames.

First of all, any given window or framed glass door will offer a certain degree of sound attenuation; whether this degree of attenuation is adequate or poor is another issue. Within the European Union, standard (run-of-the-mill) windows and framed glass doors are regulated by law to provide a minimum acceptable degree of sound attenuation. Though specifications from country to country vary slightly, on average, standard frames are required to provide a minimum sound barrier of anything between 20 and 30 db, depending on whether the frame is installed in a quiet or urban area. If the occupant requires a higher degree of sound attenuation, then the seeking of advice for the installation of a proper specified soundproof window or framed glass door should be considered.

It should be noted that for every increase of 6dB in sound attenuation, the effectiveness of a soundproof barrier is doubled, meaning that the sound penetration is cut by half. A difference of 12dB therefore, means 4 times the sound attenuation, and 18dB, 8 times the sound attenuation, etc...

Specified soundproof windows and framed glass doors for domestic applications usually start at a minimum specification of around 32-33dB, and reach a maximum performance of around 51-53dB (for a single frame window / single frame door system). In order to achieve reasonable performance in noisy areas, especially where traffic is concerned, a specification of not less than 40-42dB is recommended.

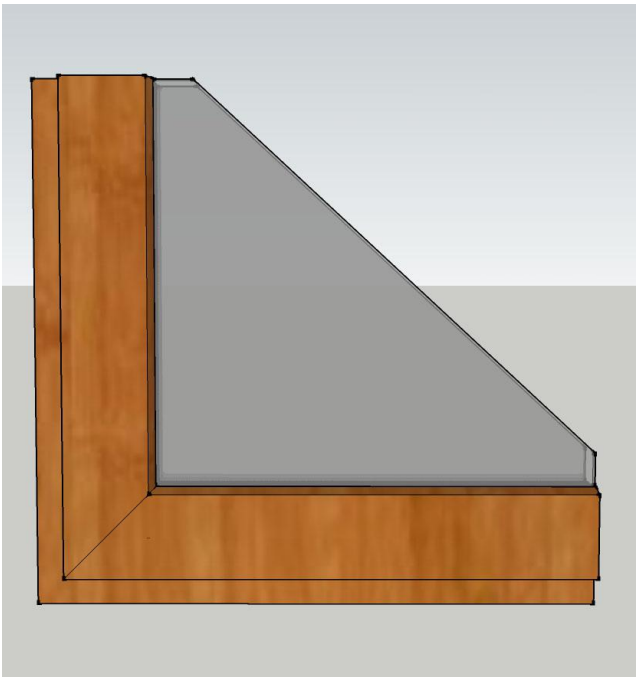
Design of soundproof windows and framed glass doors

The effectiveness of a soundproof window or framed glass door is obtained by a collective number of design considerations working together at the same time, namely:

- Air-leakage
- Glazing
- Rubber seals
- Frame construction
- Proper installation

- Closure mechanism

The ergonomics of soundproofing are unfortunately such that failure in any one of the above design factors will translate into the failure of the soundproof barrier to deliver the desired specification. The best way to undserstand this is to imagine a theoretical scenario with a window or framed glass door installed into the side of a water tank - one pinhole, and the water will leak out of the tank.



Soundproof window (exterior view)

Soundproof window (interior view)

Air-leakage

Air-leakage, apart from causing implications with thermal efficiency, also carries sound. In theory, the ideal air-leakage through a soundproof window or framed glass door should be zero, but in practice a specified air-leakage of around 0.1 % to 0.3 % is considered important. This negligable amount of air-leakage allows for a minimum amount of air-exchange, which is an important health consideration.

Glazing

At least two glass panes are specified, the volume between panes being filled with % air / % vacuum or c90% argon and hermatically sealed. The viscosity of argon (as opposed to air) limits the amount of convection within the sealed chamber, therefore reducing the transfer of heat across the glass assembly. In any case, argon filled

chambers are much more related to heat efficiency than they are to actual soundproofing. The glass panes are sealed together via a sound- and heat-insulating perimiter seal, directly bonded to each pane on both sides by means of a special bonding agent. In triple- and quadruple-glazed frames, the separate inter-chambers are individually sealed from one-another with separate perimiter seals.

A glazing unit can be assembled using standard glass, acoustic glass, laminated glass, security glass or combinations of these glass panes. Acoustic glass is standard glass coated with an acoustic film on the side facing the air-gap, so it cannot be touched or wiped, as it is easily otherwise scratched. Laminated glass consists of two pieces of regular glass sealed together with a vinyl interlayer. Acoustic laminated glass replaces the vinyl interlayer with an acoustic interlayer. Security glass is a stronger version of laminated glass and comes with the same options. Both acoustic and laminated glass offer a much better sound barrier than standard glass. Laminated glass is also a lot stronger.

UV films may be optionally added to glass panes in order to limit penetration of the UV wavelength bandwidth, though this has nothing to do with soundproofing, or obviously the restraining of the infra-red spectrum.

The presence of a third, or third and fourth glass pane is again related to thermal efficiency but also increases soundproofing specifications. Of utmost importance for effectiveness of soundproofing is the width of the gap between any two given glass panes. Two superior glass panes with a larger gap between them can perform acoustically as well as three panes with two smaller gaps between each pane.

- **Gap between glass panes**

The issue with a small gap between glass panes is related to the volume of gas sealed in-between them. If a glass pane vibrates, it tends to compress the gas within the sealed volume and transmit the vibration to the adjacent glass pane. The smaller the volume of gas, the more compression will be applied to the gas, and therefore the higher the pressure (and vibration) transmitted to the second glass pane. A larger gap means more sealed volume, less compression for the same amplitude of vibration of the glass, and therefore less transmission of sound between panes.

A specified double-glazed window or framed glass door generally uses a minimum gap of 15-16mm between glass panes, and an air-gap of 20mm for the higher specification frames. Triple-glazed units usually employ slightly smaller gaps.

The aluminium strip (drip-cap) lining the perimiter between panes is a moisture collector. The minute holes present in the strip allow the dessicant under the strip to absorb moisture and prevent condensation on the glass between the sealed panes.

The amount of dessicant present is designed to handle the sealed volume of gas within the glass pane assembly without becoming over-saturated.

- **Glass thickness combinations**

Considerations of how glass panes work together is also important. Each glass pane, like any other material structure, has a resonant frequency. This is the frequency at which it will most likely be happy to vibrate on its own, the actual frequency being dependant on the glass consituency and thickness. If two glass panes of identical constituency and thickness are used, vibration of one glass pane will most likely cause the adjacent pane to vibrate in sympathy, therfore transmitting sound between panes. Higher specification soundproof windows and framed glass doors usually use glass panes of different thicknesses to avoid this issue.

The most common glass thicknesses used in soundproof windows and framed glass doors are combinations of 4mm, 5mm and 6mm panes.

Rubber Seals

Rubber gaskets are deterimental to providing a hermatic seal to the window or door assembly in order to avoid air-leakage, and therefore transmission of sound through air. Many such frames with claimed “high specification” glazing fail because they don’t then seal properly when closed, resulting in unjustified waste of money.

Closure seals - Specified soundproof windows and glass frame doors use at least 2 separate gaskets, meaning the openable frame (on closure) is sealed along two separate sealing contact perimiters. At least one of the gaskets is a “bubble gasket”. The higher specification units use 3 gaskets.

Glass pane seals - The glass pane assembly is fitted to the frame via rubber gaskets, so that it is never in direct contact with the frame or any frame retainers present. These gaskets provides a permanent seal between the frame and glass pane assembly, cutting off the passage of air and heavily reducing impact noise transmitted from the frame to the glass pane assembly. The glass pane seals are never broken unless the glass pane assembly needs to be replaced.

Although standard windows and framed glass doors allow various types of rubber to be used in seals (Namely *Chloroprene Rubber*, *PVC Nitrile*, *TPM*, *EPDM* and *plasticised PVC*), *Neoprene* rubber is preferred for specified soundproof aperture units. 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), making it

widely used in all soundproofing applications. Other good but less effective viable options for gaskets employed in soundproofing are *cross-linked silicone* and *TPE (Thermoplastic Elastometers).* PVC gaskets are not allowed in soundproof windows because this material deteriorates when exposed to weathering, and also naturally over time, therefore eventually breaking the seal.

Frame

Frames for specified soundproof windows and glass frame doors are universally available as follows:

- 100% Wood or laminate
- 100% UPVC
- Composite Window – Wood / Aluminium skin or Laminate / Aluminium skin
- Composite Window – UPVC frame / Aluminium skin
- Sandwich frame aluminium with acoustic / thermal break

All joints constituting the frame should be either welded, glued, cleated or screwed, depending on the material employed, and should have flush, stepped or lapped surfaces. Under no account should there be visible gaps in any joint.

100% aluminium is generally acceptable for the production of frames for standard windows. It is hardly ever used with a single frame in specified aperture soundproofing applications because aluminium is brittle and has poor acoustic absorbtion properties, much more easily allowing lower frequencies and impact noise through it, even if the frame cross-section is not solid. Aluminium is also a good conductor of heat and therefore also performs poorly as regards energy efficiency. (100% aluminium frames allow the transfer of an appreciable amount of both heat and sound through the frame, irrelevant of applied glazing).

In cases where compliance with local planning authorities is required and/or an external aluminium finish is desired, composite windows provide an aluminium outer cladding (skin) fitted to a main frame made of wood, laminate or UPVC. In this case, the acoustic specifications are reached as sound is more easily transmitted through the external aluminium skin, but less easily through the next material which constitutes the bulk of the frame.

Total thicknesses for good quality double-glazed specified soundproof windows and framed glass doors, typically vary between 58 and 90 mm.

Irrelevant of the composure of the material of the frame, the design and operational criteria are always the same.

In order to use aluminium more efficiently, one has to consider a sequence of two or more cascaded frames which are consecutively isolated from eachother by an acoustic/thermal break. However, although the thermal break stops heat from reaching the inner frame by conduction, it cannot stop heat from travelling to the second frame by radiation, and therefore aluminium frames can never perform as well as wood or PVC if one is mainly considering energy efficiency, especially in hot countries where the temperature escalates to above 33º Centigrade. High performance aluminium frames can reach total frame thicknesses of around 20 cm or more.

Installation

In any soundproofing application, the actual installation accounts for a great deal of the final performance of the applied structure. Too many perfectly certified windows and framed glass doors fail because the installation is not carried out properly. A poor installation can seriously degrade the performance of a perfectly good window or framed glass door by up to 8 times, and under the circumstances it is of utmost importance that the installers are trained in soundproofing techniques, know exactly what they are doing, and that meticulous care be taken during the whole process.

The installation of a soundproof window or framed glass door takes more or less double the time required to install a standard unit.

All specified soundproof windows and framed glass doors come with a certificate of performance, stating the structure sound barrier in dB's among other values. and because it is impossible to test a window or door before it is actually installed in place, it is of utomst importance that this certificate is always requested when considering purchase

- **Fixation of frame to the aperture**

Doors:

The floor rail should be fixed to the floor via a 2-2.5mm thick strip of acoustic neoprene matting rated at around -18dB, cut to the size of the rail and fitted in-between the rail and the floor. The acoustic matting has two purposes: the reduction of impact noise transmitted from the floor to the frame by a factor of 8, and the ability of the elastic mat to compress more at certain points and less at others, therefore sealing of any passage of air due to discrepancies in floor levelling or grooves between floor-tile edges.

The other three sides (the verticals and the top) of the frame should be fixed to the aperture with appropriate screws, leaving a space of c 1cm between the frame and the aperture all the way round. This space is filled with expandible foam and an additional (finishing) batten is used via an inter-lying neoprene strip, both on the inside and outside in order to cover the foam insert. 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.

Non-rusting screws (stainless steel, aluminium or brass) should be used for fixation of the outer frame to the aperture. (Rusting causes inflation of the screws, with the possibility of applying enough pressure to warp the frame, resulting in consequences later explained below).

The combination of the acoustic floor matting and the expandible foam perimiter helps to "float" the frame within the aperture with minimum points of contact, therefore minimising on transmission of impact noise.

Windows:

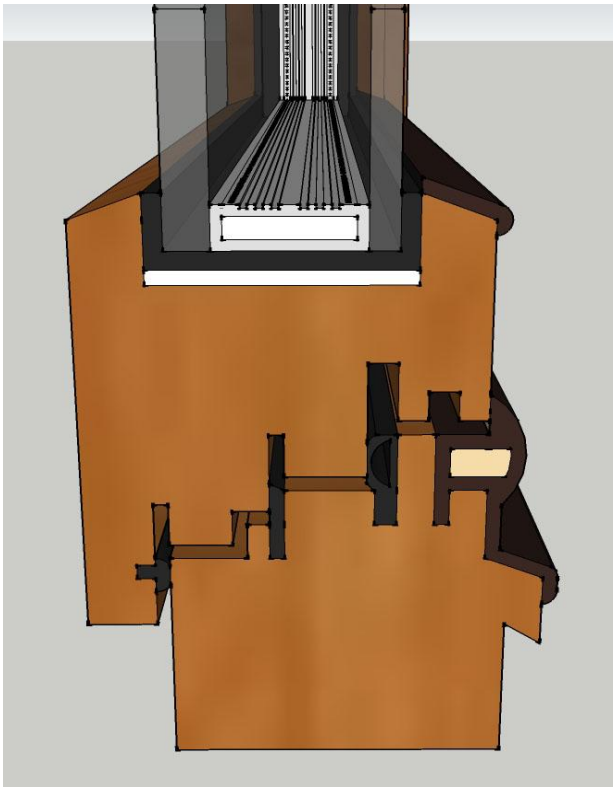
The window frame should be manufactured slightly smaller than the aperture, allowing a (circa) 8mm to 1cm space all the way round. This is similar to the technique employed for the door with the exception of the floor rail, which is not required. The rest of the installation is identical to that employed for the door (less the floor rail).

Sealing issues:

Use of silicone or acrylic compound is inadequate <u>on its own</u> for the sealing of soundproof frames to apertures for the following reasons:

- These materials do not have adequate acoustic properties to sufficiently seal off a <u>straight line</u> gap, crack or fissure to the other side.
- They are applied only to the edge of the frame on both sides, leaving the gap through the thickness of the frame untreated.
- They are not sufficiently weather resistant and tend to deteriorate over time. The seals eventually break, allowing the passage of air and therefore sound.

In such applications, silicone is in fact often used as a second seal (over the primary seal). When soundproof windows and framed glass doors are in fact usually tested, it is required that breakage of silicone seals should not in any way affect the performance of the whole assembly.



Soundproof window showing 3 seals, wide air-gap and panes of different thicknesses

- **Alignment of the frame**

Frame alignment is of utmost importance - frames warped even slightly by unequal or excessive tensions applied to fixation screws will not allow the closure rubber seals to sit properly, resulting in poor performance. In addition, warped frames transmit unnecessary stress to the glass panes, making them more liable to cracking.

Closure Mechanisms

Some manufacturers tend to quote only the specification of the composite glazing structure to represent the performance of the whole window or framed glass door. This has noithing to do with the resulting performance of the complete unit which is also involving the frame, type of build, gasketing and closure mechanism. It is useless specifying Eg: 42 dB for the glazing if for the sake of the argument, the frame supporting the window or framed glass door does not provide proper closure.

The best closure mechanaisms are invariably “Tilt & Turn”, “Lift & Slide” and “Tilt & Slide”, due to the fact that turning the handle to secure closure involves a mechanism which tightens the frame against the gaskets with equal pressure. These frames are technically considerably superior to classic frames in the tramsfer of both sound and heat, and cannot currently be matched by any other frames.

“Tilt & Turn” in particular is not just (as many would percieve) a glorified way of opening a window – it is a technically manufactured mechanism which offers both acoustic and thermal isolation incorporated not only in the frame and glazing, but also built in to a multi-gasketing system of closure.

Choice of Frame Layout

The best soundproofing is provided by single-leaf windows ie: opening like a door with the hinges on one side only. Double leaf windows suffer a drop in specification for the same frame and glazing as the single-leaf counterpart, due to the central seam between panes. Given the right type of aperture, this problem can sometimes be solved by the employment of 3-gate windows, ie: three panes with a fixed central pane. In this way, both windows are sealing shut against a fixed (rigid) perimiter.

Other Important Window Specifications to look out for

- **U-Factor**

The U-factor (or Thermal Transmittance) measures the rate of heat flow through the the window, this being mechanically transmitted through the window structure between the inside and outside air in contact with the window surfaces. It represents the flow of heat (in W) through 1 m^2 of a structure, when the difference between the two surrounding temperatures is 1 K (or 1 ºC). The thermal transmittance coefficient is expressed in $W/(m^2K)$. The lower the coefficient, the better the structure insulates.

** Sometimes this specification is expressed as R-value (or Thermal Resistance), where the R-value is the inverse of U-factor or (R = 1/U). In this case the higher the coefficient, the better the structure insulates. R-value is expressed in $(m^2K)/W$

- **Solar Heat Gain Coefficient (SHGC)**

The SHGC (Solar Heat Gain Coefficient) measures the fraction of incident solar radiation which is admitted through the window, and is therefore expressed as a number between 0 and 1. In a hot, sunny climate with high air conditioning bills, a low SHGC is desired, especially on the east and west sides of your home. (North windows don't see much sun, and south windows are relatively easy to shade, at least during the summer when the the sun is high in the sky). If you live in a cold climate with high heating bills, you should choose windows with a high SHGC, especially on the south side of your home.

- **Visible Transmittance (VT)**

The VT (Visible Transmittance) measures the fraction of incident light which is admitted through the window, and is also expressed as a number between 0 and 1. The lower the VT, the less light is admitted through the window. VT is controlled by applying a tint to the glass.

FAQ

Q. I'm interested in purchasing a double-glazed window. Does that mean that it's soundproof?

A. Not necessarily. You can have a non-soundproof window which features double-glazing. Less than 32 dB does not fall within the "soundproof" range.

Q. I have been offered a glazing combination which reaches 37 dB. How soundproof is that?

A. Be careful. The sound barrier rating should be quoted for the complete window and that includes the frame, not just the glazing. There is a big difference in build and features between standard frames and soundproof frames. 37 dB requires a soundproof frame. All soundproof windows and framed glass doors are tested in a lab and come with certificates – ask for certificates.

Q. I had a certified soundproof framed-glass balcony door installed. If my friend stands on the other side of the closed door and I call his mobile, I can hear it ringing.

A. The door has not been installed properly. The required installation technique for soundproof apertures is substantially different from that for standard apertures. If your soundproof door or window has been installed using the technique for standard apertures, it will fail.

- **Get in touch with reputable manufacturers or distributors**
- **Ask for certificates**
- **Use certified installers**