Examining the Acoustical Soundproof Plumbing System in Buildings: A Prospective Approach

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Abstract: When installing internal pipe work in high-rise apartment buildings or multi-occupancy buildings, acoustic drainage is crucial to ensure that the occupants or tenants are not disturbed by the sound of running water or vibrations from the pipes. Acoustic plumbing aims to combat the issue of internal noise pollution by containing the sound within the waste and drainage pipes. Acoustical soundproof plumbing systems are pipe solutions that minimize noise transmitted through the pipes in the building. Anywhere a pipe passes through a fixed wall or floor and is physically fastened, pipe insulation can stop noise transfer by dampening the pipe wall and serving as an acoustic decoupling device. This research paper presents a comprehensive overview of the acoustical soundproof plumbing system and the strategies and latest technologies to reduce the noise in the buildings.
Keywords**:** acoustics, soundproof, plumbing, drainage, pipes, building services, architecture

1. Introduction

Everyone has heard the terrible sound of the toilet in the hotel room next door flushing in the middle of the night, and it's much worse if you've spent a few thousand dollars on the experience. The reasons for internal noise from service installations like lifts, heating, air conditioning and waste systems are frequently underestimated and ignored by developers and consultants, who examine the sources of exterior noise like air and traffic. The noises produced inside the pipelines by the falling liquid cause them to vibrate when a waste system is activated. One of the main ways that noise moves from one area of a structure to another is through pipework. The majority of the noise produced travels through the pipe as air-borne noise (Figure 1). However, this vibration is known as structure-borne noise because it travels from the pipe walls to the surrounding region, the bracketing systems, and ultimately the building structure (Figure 2).

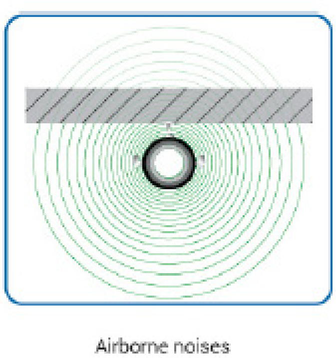

Figure 1. Air borne noise.

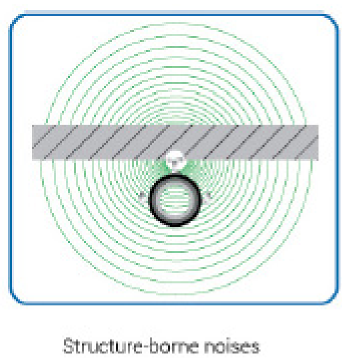

Figure 2. Structure borne noise.

By keeping noise inside the drainage and waste pipes, acoustic plumbing seeks to address the problem of indoor noise pollution. Anywhere a pipe passes through a fixed wall or floor and is physically fastened, pipe insulation can stop noise transfer by dampening the pipe wall and serving as an acoustic decoupling device. Selecting a system with improved soundproofing performance is crucial for reducing noise levels in drainage and waste systems, in addition to making sure the waste circuit is mounted correctly and the system is constructed appropriately (Adlakha, 2019).

2. Causes for Noise

One of the most frequent complaints from building residents who are unhappy with the comfort of a building is noise from nearby occupants. The Sound Transmission Class (STC) refers to a building system's noise performance. The system's ability to isolate airborne noise improves with increasing STC. An element with an STC rating of 50 lowers the sound waves that travel through it by 50 dB. The majority of noise problems in buildings are caused by either (a) airborne noise or (b) noise that is carried by the structure. Common sound sources like radios, televisions, and voices are usually the cause of airborne noise. When a portion of the building fabric is affected, either directly or indirectly, structure-borne noise—also known as impact noise—is created. The energy makes noise in adjacent rooms as it travels through the building's structure. Heavy footsteps (especially on exposed wood or hard floor surfaces like tile), slamming doors, furniture scraping, vibrations from loud music, and plumbing sounds are a few examples. To solve the airborne noise, mass is needed. When it comes to managing structure-borne noise, isolation and vibration breaks are more important than mass. This is the exact opposite of solving airborne noise. For many years, popular solutions to some noise problems—like improved in-floor systems and various party wall configurations—have been used with good results. Plumbing system noise is one area of noise abatement that is still being worked on, though with varying degrees of success. One of the most annoying and challenging noises to reduce is plumbing noise. Unfortunately, the problem of reducing plumbing noise is thought to be economically impossible. Recent advancements regarding the availability of products and support services now make the mitigation of plumbing system noise easier and more effective (Jain & Kamal, 2023).

3. Contributing Factors of Noise in Plumbing System

Following are the four main categories comprising a building's plumbing system and how these systems create noise.

3.1 Drainage Systems

a) This category comprises roof drain piping that receives drainage from deck drains, roof drains, and other such receptacles at variable rates and volumes, as well as sanitary waste piping that receives drainage from plumbing fixtures and appliances at variable rates and volumes.

b) Roof drains, rain leaders, deck drains, condensate drains, and sanitary drains are examples of drainage piping that receives gravity flow from common plumbing fixtures including sinks, washbasins, toilets, bathtubs, and showers. Drainage plumbing that receives liquids under pressure and on an intermittent basis includes funnel drains in mechanical rooms, dishwashers, and washing machines.

c) In each of these situations, the quantity of airborne and structure-borne noise produced is directly influenced by the density and wall thickness of the pipe and fittings. The quieter the pipe's operation, the thicker and denser the wall construction.

d) A drainage liquid moving vertically in a gravity system sticks to the pipe's exterior walls and moves in a spiral pattern. Very little noise is produced in this setting. When liquids and solids strike fittings at directional changes in the piping system, particularly when a vertical stack strikes a horizontal pipe, the flow of the pipe's contents produces the most noise. In drainage systems made of plastic, it is most obvious.

e) When drainage piping undergoes thermal expansion and contraction as a result of temperature changes, it also produces noise, particularly in plastic systems.

3.2 Water Distribution Systems

a) Water distribution systems include industrial water, process, and HVAC piping that all supply water under pressure to different equipment components within a building; non-potable water piping that supplies water under pressure to systems like irrigation and mechanical equipment; and domestic/potable water piping that supplies water under pressure to plumbing fixtures and appliances throughout a building (Kamal et al., 2016).

b) The simple flow of water caused by a fixture or tap operating is a common source of noise in a water system. Water pressure, flow velocities, undersized tubing, turbulence from direction changes, and obstructions in valves and equipment are some of the elements that promote noise generation in this situation. Direct contact between the pipes of the water system and the different parts of the building is the main contributing factor.

c) A water hammer, which happens when water moving quickly stops abruptly, is another common noise maker. This happens when valves are closed rapidly, causing the pipes to shake and creating a shock wave in the system. Appliances with electric solenoid, or fast-closing, valves, such as dishwashers, ice makers, and washing machines, are among the main plumbing components that contribute to this issue. Commercial buildings' water closets and urinal flush valves are additional frequent sources.

3.3 Fixtures, Faucets, Appliances, and Appurtenances

a) In addition to producing airborne noise, fixtures that come into direct touch with building components — like a bathtub or shower pan — also produce a significant amount of structure-borne noise.

b) Stainless steel, cast metal, plastic, or brass (with various plated finishes) are commonly used to manufacture faucets. The degree of direct contact with the fixture they service or the building itself, like a ceramic tile tub deck or hard surface countertop, is influenced by the wall thickness of these things, which also affects how much noise is produced.

3.4 Valves, Pumps, and Equipment

a) The amount of friction and turbulence that valves produce determines the noise levels that they produce. For example, globe valves have a high turbulence due to their design, which makes them quite noisy.

b) Pumps are frequently extremely noisy, particularly when they are in close proximity to building elements or are piped improperly, which causes cavitations and turbulence. Through vibration, the apparatus produces noise at a wide range of frequencies.

4. Materials Used in Soundproof Plumbing System

The soundproof pipes and fittings are made of polypropylene and mineral field polypropylene compounds. These pipes have triple layers: External layer, middle layer and internal layer. These soundproof pipes have polypropylene for the top and bottom layers and mineral-filled polypropylene compounds (PP-MD) for the middle layer as shown in Figure 3.

Figure 3. A three-layered pipe.

a) All materials comply with the RoHS (Restriction of Hazardous Substances) directive and are Halogen and Cadmium free. The composition of triple-layer pipe is as follows:

b) The external layer is made from black PP (Polypropylene) marked with the manufacturer's trademark in green stripes – that provide UV-resistant performance.

c) The middle layer is made from PP-MD (Polypropylene and mineral-filled compound) that provides acoustic insulation.

d) The internal layer is made from white PP (Polypropylene) that provides high-performance inflow and contrast for visual monitoring and control.

e) Fittings are made from PP-MD (Polypropylene and minerals compound) that provides acoustic insulation.

f) All products are connected using push-fit insertion, with single lip high-quality seals made of SBR-NR.

5. Modified and Advanced Fittings

Figure 4 shows a diagram of standard pipe fitting. The ultra-silent fitting has a swept edge with the branch, which improves the flow rate and reduces turbulence flow and accompanying airborne noise (Figure 5).

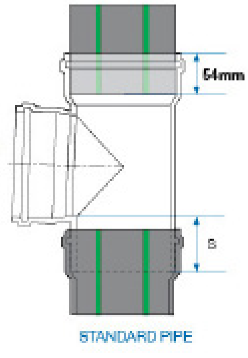

Figure 4. A standard T junction fitting.

Figure 5. Fitting joint with swept edge.

All fittings are made from black PP MD for outstanding acoustic insulation and are connected using push-fit insertion with single lip quality Styrene Butadiene Rubber - Natural Rubber (SBR-NR) seals to provide leak-proof performance and noise reduction (Figure 6).

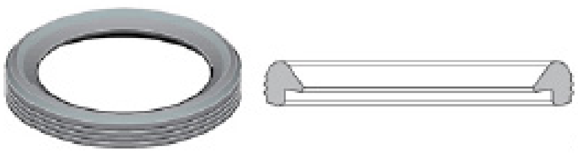

Figure 6. Styrene Butadiene Rubber – Natural Rubber (SBR-NR) Seals.

Figure 7 shows the points where maximum acoustic vibrations are generated on the downpipe.

Figure 7. Points of maximum acoustic vibrations.

The three-layer, soundproof system serves as a barrier to stop noise from spreading. Additionally, sound waves are partially absorbed by the material media, and this partial inward reflection greatly lowers transmission to the surrounding environment. Acoustic resonance in pipes and fittings is caused by the waves that are absorbed and reflected. The resonance is more dynamic inside the building (Figure 8). Resonance rises in the direction of the wastewater flow and is transferred to the building's structure via the pipe clamp attachment system. Sound waves are transmitted to adjacent rooms through construction barriers that are susceptible to acoustic resonance transmission. The structure of the Huliot system and acoustic clamps are what minimize this acoustic phenomenon to the greatest extent possible.

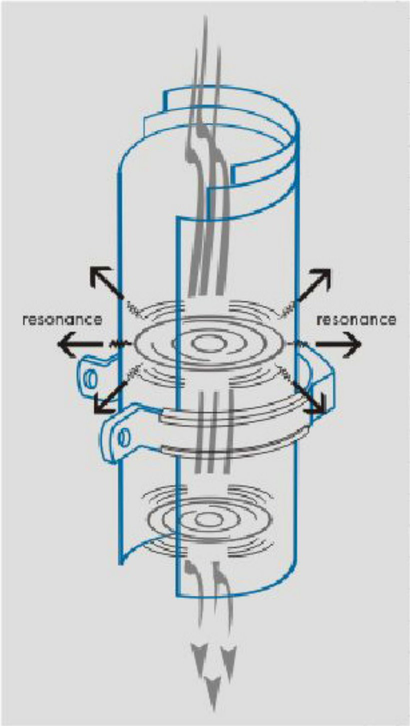

Figure 8. Transmission of resonance.

To reduce the noise of vibrations coming from the pipe system, acoustic pipe clamps, have been designed. A special body section and the use of elastomer inlays provide a stable grip while maintaining acoustic properties. Cushioning inlays are placed inside the pipe clamp at three points that do not take part in tightening the pipe clamp to the building's structure. The active circumference of the pipe clamp is asymmetric after its opening, which facilitates keeping the pipe vertically before it is mounted inside the pipe clamp.

6. Noise Levels that are Acceptable

The maximum amount of noise that a person can tolerate while going about their daily business and unwinding are given in Table 1.

Table 1. Acceptable Noise Levels in various living spaces.

Space Typology	The allowed average noise level that is produced by the building's technical equipment as well as other equipment both within and outside the structure.	
	Day (db)	Night (db)
Spaces intended for mental exercises requiring a high level of focus.	30	-----
Rooms in 3-star or below 3-star hotels	40	30
Accommodations in four-star hotels, boarding schools, children's homes, senior citizens' homes, and residential buildings.	35	25
Rooms in Intensive medical care units	25	25
Hospital and sanatorium patient rooms, with the exception of acute care units.	30	25
Kitchens and sanitary rooms in flats	42	40
Other Built-up areas	60	50

Note: With Huliot's advanced system, the noise level can be reduced to 20 dB.

7. Advanced Soundproof System Installation

7.1 Distribution of Pipe Clamps and Barrier Passage

One important element in the design and installation of the system is the distribution of pipe clamps. Distances are provided. The proper method for running a soundproof duct through a construction barrier is shown in Figure 9. A sleeve composed of a material that keeps out moisture and guarantees acoustic insulation should be used to protect each route (Nash, 2017).

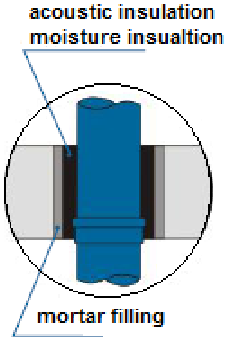

Figure 9. Details of passing a soundproof duct through a construction barrier.

7.2 Clamps

The system should be fitted in conjunction with specially made acoustic pipe clamps in order to preserve acceptable acoustic qualities. Depending on the downpipe diameter, there are two types of acoustic pipe clamps (Figure 10) shows clamps for pipes up to 110 diameters. For pipes and fittings of 125 and 160 diameters, which have higher weight require different designs of clamps (Figure 11).

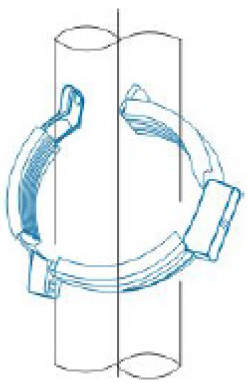

Figure 10. Clamp to reduce the transfer of vibrations (pipes up to 100 mm diameter)

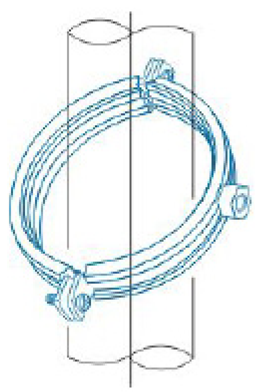

Figure 11. Clamps for pipes 125 to 160 mm diameter.

7.3 Laying Connection inside Buildings

Typically mounted on ceilings, outdoor wastewater collectors should be constructed using steel pipe clamps with rubber inlay and acoustic materials, secured with screws. The pipe clamp spacing is 10 d. (Figure 12).

Figure 12. Clamps with rubber inlay.

7.4 Stabilizing Sections

'Short' stabilizing section: In the case of downpipes up to 10m high, a change of direction from the downpipe to a horizontal connection should be made with 2 x 45° bend connections and one pipe section of L less than 240 mm. 'Long' stabilizing section: In the case of downpipes over 10 m high, the length (L) of the section between bend connections should be L = 240 mm (Figure 13).

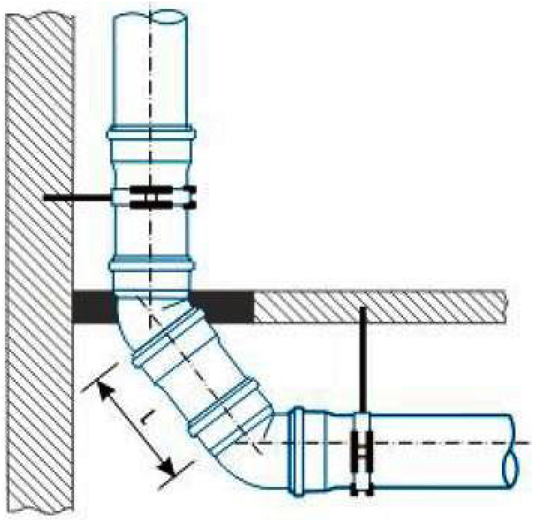

Figure 13. The detail of stabilizing section 'L'.

7.5 Pipe Offset

In structures taller than seven stories, offset pipes should be placed every seven to eight stories, beginning at the top of the downpipe, to block the energy of wastewater containing additives that are falling quickly (Figure 14).

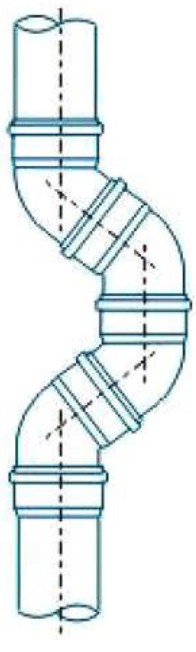

Figure 14. Offset of the pipes.

7.6 Horizontal Change of the Flowing Waste Water Direction

Make sure the pipeline is laid with 45° fittings (rather than 90°) when the wastewater flow direction is changed by 90°. The system's acoustic qualities are improved by this slight change in flow direction, which results in some energy loss from the wastewater flowing (Figure 15 and Figure 16).

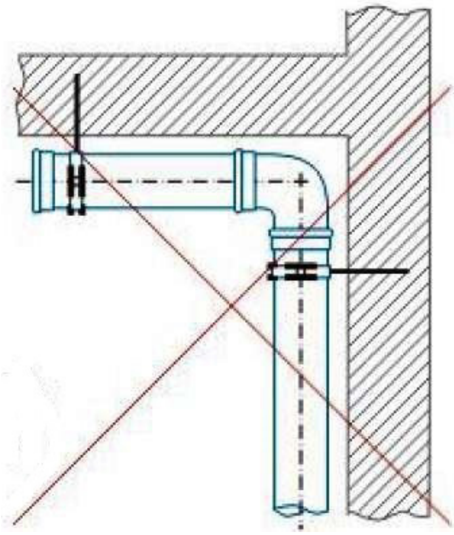

Figure 15. Incorrect way of using 90°joint fitting.

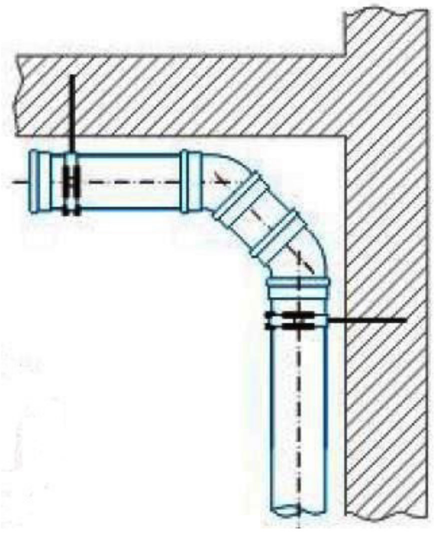

Figure 16. Correct use of 45° joint fittings.

7.7 Isolation Details

Insulating materials like felt, rubber, and other isolation liners can be used to reduce the amount of noise and vibration that is transmitted to the building's components (Figure 17 to Figure 24).

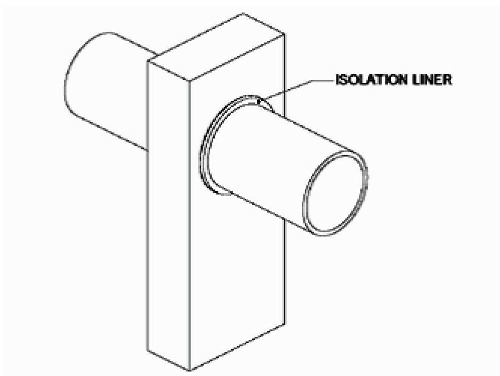

Figure 17. Isolation of the pipe through a framing member.

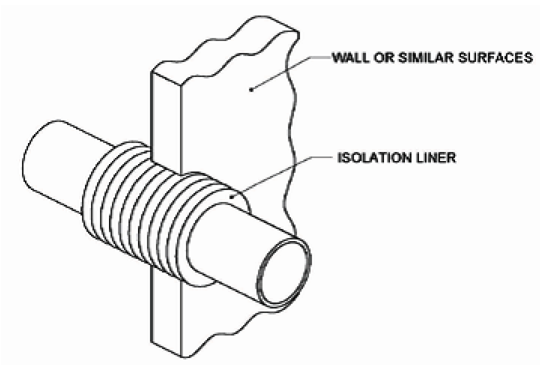

Figure 18. Resilient pipe isolation.

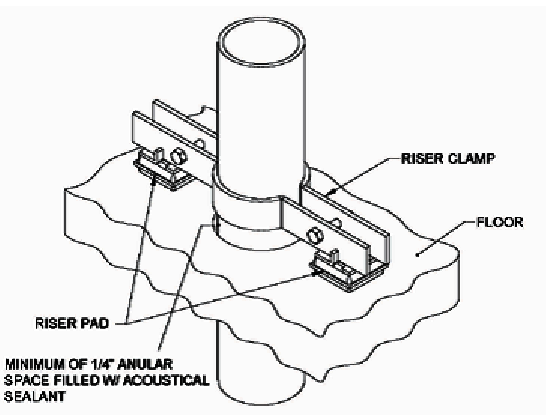

Figure 19. Clamp isolation of a riser.

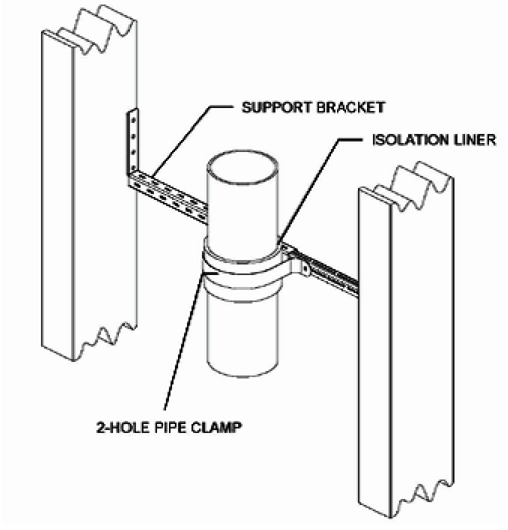

Figure 20. Mid-span support of a vertical pipe.

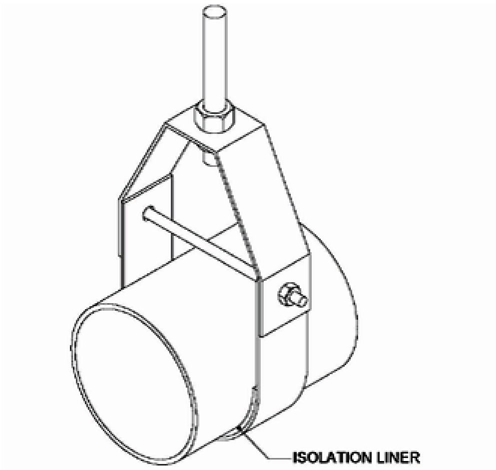

Figure 21. Suspended waste, vent, or other piping.

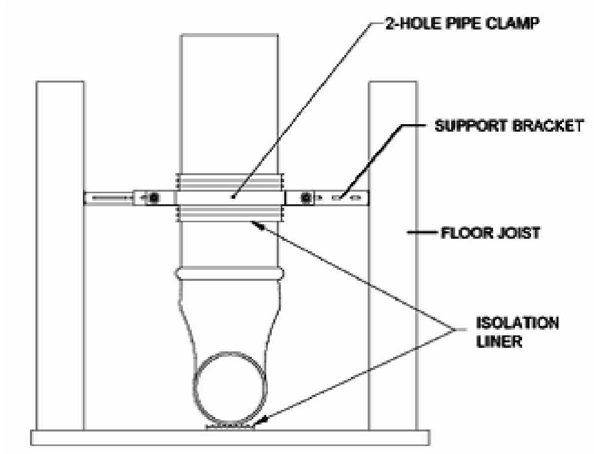

Figure 22. Isolation of toilet fixture waste pipe.

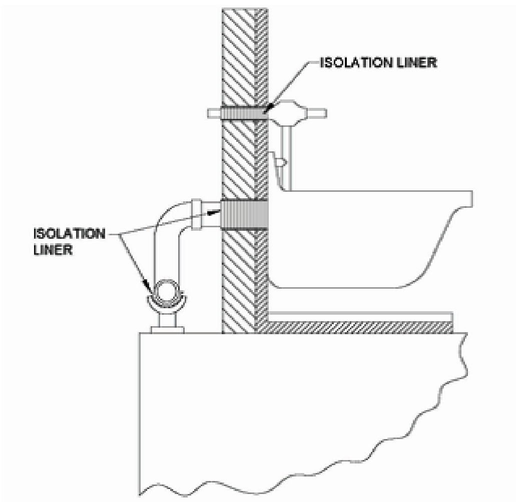

Figure 23. Water closet of wall hung type.

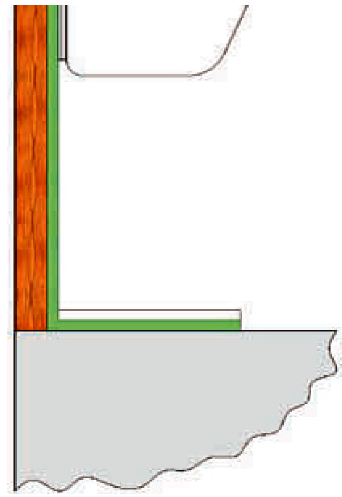

Figure 24. Wall mounted urinal, sink, or similar fixture.

8. Conclusions

This paper provided a thorough review of the acoustical soundproof plumbing system, as well as the newest technology and tactics for lowering noise levels in buildings. Acoustics must be taken into account by engineers and architects when developing high-rise building utility and piping systems. Effective acoustic design can improve residents' and tenants' comfort levels and aid in sound control, both of which enhance their enjoyment of the space. These piping system are algae and bacteria-proof. They are not prone to abrasions and are inflammable. They are electrically insulated and have high internal smoothness. These pipes are shock and corrosion resistant. They produce noise less than 35 dB. Selecting a system with improved soundproofing performance is crucial for reducing noise levels in drainage and waste systems, in addition to making sure the waste circuit is mounted correctly and the system is constructed appropriately. Every pipe material must be free of halogen and cadmium and adhere to the RoHS (Restriction of Hazardous Substances) directive.

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