Overcoming Acoustic Challenges in a Heating World

Con-form GROUP

Making it *Easy*

Contents

Overcoming Acoustic Challenges in a Heating World

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At Con-form Group our day-to-day experiences with large-scale construction projects across the nation are demonstrating to us that the issues of rooftop HVACR noise are continuing to be ignored until buildings are being completed.

This is to the detriment of those building companies which are discovering that they are being faced with costly ‘fixes’ and delays to entry of those sites.

Our goal is to provide you with an understanding of these acoustical issues, so that you can advise the key project decision makers of your projects to approach these matters with a sense of urgency at the outset of their projects.

In the past, commercial-retail-industrial buildings featured basement or ground-level plant rooms which housed all of the necessary HVACR (Heating, Ventilation, Air Conditioning & Refrigeration) equipment. The compressors, pumps, condensers, etc.

As building footprints diminished in size this equipment was transferred to the roof.

Many people don’t focus on the connection between air conditioning and the world at large. It is simply a necessary convenience.

In short, as we make internal environments cooler we are making the outside word hotter.

This is a double-edged sword because as the planet warms due to climate change, we’ll be using our air conditioners even more.

By the same token, the more air conditioning systems that are used, the more air-borne mechanical noise pollution is created.

The issue in point is noise generated by heating-ventilation-air conditioning-refrigeration mechanical equipment.

This noise is defined within the industry as ***“unwanted sound”***.

Whilst the generation of rooftop noise is an ever-increasing challenge, to the level that it can even prevent access to newly completed buildings, there are a number of highly effective solutions which are covered here.

The Built Environment & HVACR

In our major cities people are living closer together.

Why are we living closer together?

Australia is experiencing a population boom via a dramatic upturn in immigration numbers.

Between 2020-2021 the capital cities grew by more than 205,000 people.

At the end of 2023, the Australian Bureau of Statistics reported that migrant arrivals had increased by 73% to 737,000 people. Our nation grew by 2.5% in the same year to more than 26,000,000 people.

This trend is not expected to slow down. Australia is anticipated to grow by 11,800,000 between now and 2046.

Three quarters of this growth will be experienced in Sydney, Melbourne, Brisbane and Perth.

More people... more air conditioners.

Residential blocks are becoming smaller. Commercial office buildings, light industry and even industrial parks are being developed within a short distance to built-up residential areas.

Transport hubs and major retail centres have become a mecca for high- density apartment living. It is not uncommon now to see clusters of high-rise buildings.

State Governments are talking about investing in massive expansion of medium and high density dwellings along rail and road systems.

With residential towers being constructed at a variety of different heights (i.e. different numbers of storeys), their occupants find themselves living alongside or looking down at the aforementioned mechanical equipment on the roof of the neighbouring complexes.

Uncontrolled noise emissions can dramatically impact their quality of life. This is a relatively new phenomenon which is adding to the challenge.

On the scale of 1-10... 10 being the noisiest... data centres have the loudest HVACR systems. They are a 10.

We are seeing more and more that data centres are being constructed in close proximity to their users. In other words, in the midst of suburbia.

If you take Sydney as an example, we are aware of data centres being built on the North Shore and in the Greater West which are surrounded by a sea of residential rooftops.

Australia currently boasts 306 data centres. This sector is expected to grow by another 3.6% between now and 2029.

Microsoft announced it is investing $5 billion in the construction of these vital hubs. It is their biggest investment project outside the U.S. They still have another 29 yet to commence.

What is the main contributor to this equipment noise? It is their chillers.

A typical data centre could have as many as 100 chillers on its roof. They have to operate 24 hours a day. This is because it is imperative that interior temperatures are maintained at between 18-27 degrees Celsius. Anything outside this range can lead to computer systems malfunctioning and data being lost.

Chillers circulate large amounts of water which in turn cool the air before it is sent into the building space.

They are preferred over clusters of smaller AC units because they are very efficient in cooling large volumes of air and they are more cost-effective to run.

The downside is that chillers are enormous and extremely noisy due to their rows and rows of fan units.

Whilst data centres dominate the loudest end of the unwanted noise scale, there are other buildings across the nation which can approach those higher figures. Such as hospitals and large-scale medical centres.

They too have to maintain their interiors at specific temperatures. For example, it is common for operating theatres to be kept between 20-22 degrees Celsius as this is the optimum range for worker-patient comfort and inhibiting bacterial growth.

A growing population requires more health infrastructure and as of now we are aware of $9.5 billion worth of new hospitals being built.

This figure is expected to grow over time. It does include the retrofitting of newer AC technology on older hospitals which is commonplace.

In similar fashion to the placement of data centres, there are numerous medical institutions in close proximity to residential sectors.

Another big AC user is retail, in particular, shopping centres.

Australia features 1630 major retail centres and more are in the pipeline.

The Colliers Report says in order to keep up with supplying the expectations of our growing population, Australia will need to construct another 660,000 square metres of retail space this decade. Which means AC systems will need to cool more than 2.6 million cubic metres of space.

Of the 1600-plus retail centres across the nation, 1100 are situated in the midst of suburbia.

Climate Change

According to the Australian Government, average temperatures have been rising each year. In fact, since 1950 each decade has been hotter than the one before it.

One of the outputs of this phenomenon is the Urban Heat Island effect.

This occurs when surfaces such as steel-concrete-glass buildings, dark rooftops and asphalt roads trap the heat. It leads to metropolitan centres becoming as much as seven degrees Celsius hotter than surrounding areas.

The formula is obvious:

> hotter weather + higher temperatures + more people
>
> = more AC systems

Not just more... but also bigger systems.

Currently, there are 4,950,000 AC units in Australia.

Between now and 2028 this figure is expected to go up by another 5 per cent.

Back in 2016 the total amount of energy required to power the nation's combined AC systems was 30,000,000 megawatt hours.

Almost a decade later it requires 40,000,000 megawatts hours for us to keep our cool.

Studies have shown that Australians will collectively spend at least another $500,000,000 on running their AC systems in 2024 compared to the year before.

Government

The HVAC&R industry has to comply with Building Code of Australia regulations. Namely AS/NZS 1170.1.2.4, AS1657 and AS1664.1.

There is no reference to sound attenuation of mechanical plant machinery in Standards Australia documentation.

In Victoria, the State Environmental Protection Policy (SEPP N-1) in Class 5, 6 and 9 Buildings offers a guideline for acceptable base noise limits and typical noise limits for residential, commercial and industrial properties. It states that 45 decibels (dB) is the base noise limit for during the day, 40 dB for evenings and 35 dB for night time.

It goes on to show that typical noise limits for residential areas are 50-54 dB in the day, 44-48 dB in the evening and dropping to 39-43 dB at night. The limits for commercial areas are 54-59 / 48-52 / 43-47 dB. As expected, industrial limits are higher: 63-68 / 57-61 / 42-56 dB.

Councils have their own Noise Pollution Laws and these change from region to region.

There isn't a blanket 'norm' for all locations. For example, one Council has stipulated that the noise coming from an HVAC&R system cannot exceed background noise level by more than 5 decibels at the property boundary.

For this reason, building developers need to collaborate with local government in the planning stages of their projects to ensure their structures will comply with their acoustical requirements.

From our perspective, given the number of projects we have witnessed which strike problems, this is something that is not adhered to across the board.

Construction Process

A natural segway from the previous comment is an examination of the traditional construction process.

It is due to this methodology that so many projects end in 'acoustical grief'.

Stage One is initiated when the developer comes up with the idea to produce (a data centre, shopping centre, hospital, etc.).

They search for suitable land – we have already noted that this is often near residential housing.

An architect is commissioned to draw up a Basic Plan. This is devoid of a lot of the detail of the final plans and displays a simple interpretation of the developer's vision.

The Basic Plan is submitted to Council for review. It is approved and then the land is purchased.

Next, the architect prepares the Scope of Works which includes the detailed design of the building, shadows, run off, sewer, roads, etc.

The developer and architect approach the necessary stakeholders such as the Geotech Engineer, Structural Engineer, etc

From the team's combined expertise comes the tender document which is then distributed. The builder and other contractors (plumbing, electrical, air conditioning) are selected.

The building is constructed and the developer goes to Council for final approval and the Occupation Certificate.

More often than needs be, this is when the developer is shocked and amazed at being knocked back! Council determines that building is not acoustically compliant!!!

There are multiple risks experienced by the developer in this stage. They can range from the landlord being forced to delay their retail opening and therefore losing large amounts of revenue....to angry tenants demanding access to the building and threatening legal action...to the discovery that the roof does not have the structural integrity to support additional weight (of an acoustic barrier) and therefore it requires additional bracing at great expense before a solution can be added.

At Con-form Group we have lost count of the number of times we have heard developers and building companies say, "I wish we had met you earlier"!

This is why the matter of rooftop acoustics needs to be raised at the early stages of a project and costed in before work commences.

Noise Generation

HVAC&R acoustic issues are so serious that they can prevent buildings worth many millions of dollars from being accessed.

HVACR systems are made up of a variety of mechanical components as well as many metres of ducting which snakes across the rooftop space.

The main components include the:

- Compressor
- Condenser coil
- Condenser fan
- Expansion valve
- Evaporator coil
- Evaporator fan

They combine to operate in a cyclic manner.

The compressor pushes warm refrigerant to the condenser where its fan draws in ambient air across the coil. This is mixed with super charged vapour and the hot air is ejected into the atmosphere. After travelling through the expansion valve the newly chilled refrigerant arrives at the evaporator. Here, the fan blows colder air out into the atmosphere and then the refrigerant continues back to the compressor for its next circuit.

Plant equipment emits mechanical noises of various frequencies and volumes. For example, 75kg condensers with side discharge (1x side mounted fan) emit approximately 65 decibels of noise. Those with twin fans emit around 70 dB.

If they have top mounted fans (similar in concept to chiller fans) the numbers go up. A 250-300kg condensor with a single fan will emit an average of 80 dB whilst adding a second fan increases this to as much as 90 dB.

Air drawn into fans and ducts produces induction noise. Air movement noise occurs when the air passes along the ducts.

When that air echoes inside the ducting or leaks out through the walls of the ducts it is called breakout noise. And, duct fittings and elbows can create aerodynamic noise.

A typical HVACR system produces some or all of those noise types in a variety of directions. With a range of frequencies. One side of the building can be louder than another. It is not consistent throughout the 360-degree space.

Noise follows the First Law of Thermodynamics – the Law of Energy Conservation.

Energy cannot be destroyed. It can only be transferred or transformed.

To prevent noise escaping from the rooftop environment an acoustic barrier is required.

The traditional method of arresting noise was to use sound blankets.

The blankets would decay over time because they were exposed to the elements, and therefore would have to be replaced.

They were attached to heavy frames and this was not suitable for roof structures which were unable to support a lot of weight from above.

The other disadvantage was that the blankets weren't tuneable. They provided the same level of soundproofing to all sides of a building and that meant that higher levels of noise could not be captured.

Acoustic engineers like to specify membrane material as a barrier.

Porous materials trap air inside them and trap high and low frequencies. Fibre diameter is significant. Air trapped between the fibres reacts with sound energy and is converted to heat. The more fibres per square metre of insulation the greater the surface area for absorption.

This is why two insulation membranes of the same density and thickness can vary in their acoustic performance due to having fibres of different thickness.

Con-form Group utilises a porous polyester fibre membrane material for our acoustic barriers. It is moisture- and UV-resistant as well as being fire retardant. It comes with a 10-year warranty. Plus, it is 'green' as it is manufactured from recycled drink bottles (!).

Because these membranes are extremely lightweight they can be used liberally in acoustic screens.

Best practice is to engage with an Acoustical Consultant at the outset of the building project – or in the very least invite Con-form Group to advise the stakeholders of the potential risks and explain our unique range of industry- first acoustical solutions.

An Acoustical Consultant will plot an Acoustic Map of the rooftop space showing the variety of outbound frequencies, volumes and directions. From this they will determine a number of key parameters.

The foundational factor in sound measurement is the decibel (named after inventor Alexander Graham Bell).

A fluctuation in noise of plus or minus 1 decibel is not perceptible to the human ear. Changes become noticeable at plus/minus 5 decibels.

Sounds between 50-70 decibels are deemed to be Moderate. From 70-90 decibels they are called Noisy. An example is an electric lawnmower which generates approx. 80 decibels. From 90 dB (a noisy factory) to 100 dB (pneumatic hammer) and 110 dB (accelerating motorbike) is labelled Very Noisy. Above that, Extreme (110-130 dB) includes such noises as a plane taking off or a music concert.

The performance of sound absorptive material is described by the Noise Reduction Co-efficient or NRC rating of the product.

This is a simplified single number that is the arithmetic average of four frequencies:

- 250 Hz
- 500 Hz
- 1000 Hz
- 2000 Hz

However, the NRC does not include frequencies less than 250 Hz and in some cases these bass sounds can contribute to 'unwanted sound'.

The higher the NRC number the greater the sound absorption. The highest rating is 1.0.

Con-form Group manufactures acoustic barriers with an NRC of 0.75 for less noisy spaces and others with an NRC of 1.0 for the harshest environments (such as data centre chillers).

Other criteria the Acoustical Consultant will investigate are:

- RW
- Ctr
- RC Mark II Noise Flanking Noise
- Sound Transmission Class

Rw (or Weighted Sound Reduction Index) is a laboratory measured value defined by ISO 717-1. It is a measure of how effective an acoustic barrier is. An increase of 1 Rw point is equivalent to a reduction of 1 decibel in noise transmission through an element (i.e. a wall).

The higher the index the better. For example, double glazed windows have an average Rw of 29, and go as high as 43 Rw, compared to 24 for 3mm single pane glass.

An effective acoustic barrier should be up around Rw of 50.

In some applications the Rw doesn't account for all noises on the rooftop, especially low frequency bass noises. The Ctr value is used to more accurately pinpoint the required sound insulation performance.

Rw + Ctr is influenced by the material properties of the acoustic barrier membrane. That is, the type of material, weight and thickness. The higher the Rw + Ctr value the more effective the acoustic barrier is at reducing high, midrange and low frequency sound transmission.

Flanking noise refers to the ability of sounds to dramatically deviate and not follow a linear path. An example of this would be HVACR mechanical sounds moving across an open space, transmitting through ducting walls and into the chambers, then exiting some distance from the source via the duct opening.

It includes primary reflections and secondary reflections which generate new source paths in even more directions. When these sound fields clash or overlap each other they create an unstable zone called Near Field.

STC refers to the ability of building materials to transmit noise.

Best-Practice

Here is a checklist for the ultimate acoustic barrier. When you are looking to select a solution for your project you need to adhere to ALL of these criteria.

To ignore even one of these features will compromise the end result.

The product you select must be:

- Tuneable – offering different performance based on the noise types and levels coming from each direction of the HVAC&R system
- Variable – available in a range of heights and widths to provide the right amount of mass and to properly fit the available roof space
- Scalable – it can be cost-effectively added to later on (if the HVACR system is upgraded or expanded)
- Lightweight – have frames and panels as light as possible so that the builder doesn't have to reinforce or rebuild the roof structure
- Reflect and absorb noise (2 methods)
- Be easily attached to the roof – metal or concrete, of variable pitches

And, of course, it needs to be cost-effective.

Case Study

Con-form Group was commissioned to design, construct and install a platform and acoustic barrier around the main HVACR system on a shopping centre rooftop.

However, the 'centre failed its acoustic audit because it ignored the other smaller units scattered across the roof. When the Council carried out their audit these AHU's (Air Handling Units) produced enough noise to impact surrounding residents.

Con-form Group returned to the site with custom-designed acoustic barriers which were produced to suit each individual piece of equipment: their unique dimensions, noise levels, noise radiation sphere and direction of the outbound noise.

As a bonus to the developer, the screens were painted in a popular Colorbond colour (Surfmist) so that they aesthetically blended into the roofscape.

Surfmist

Fortunately, the building company was saved from having to face a worst-case scenario (these crisis situations have the potential for tenants to take legal action over lost revenue and extra expenses related to the delay in being able to enter the premises to fit out their shops and unload stock).

It is this type of last-minute 'fixing' that we are attempting to remove from the marketplace. To prevent heartache and added costs.

Effective Acoustic Solutions

Con-form Group developed the HVACR industry's first turn-key rooftop system.

We have been active in this marketplace for over two decades and our expertise enabled us to pioneer products which have become the automatic go-to for projects for the likes of Amazon, Microsoft, Google, Woolworths, Coles, Aldi and numerous others.

This system consists of:

- Lightweight, modular prefabricated steel platforms
- Acoustic barriers and visual screens which are also lightweight and modular
- Lightweight walkways, stairs and access systems

These components are dramatically lighter than traditional structured steel and because of their prefabricated design they are easily moved into place and can be installed in days or weeks instead of months for traditional methods.

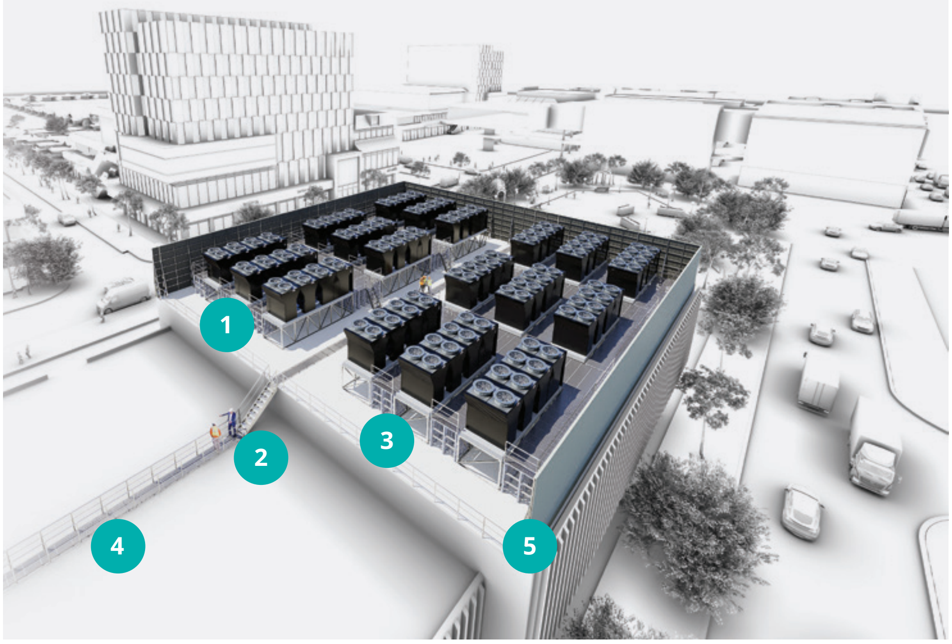
1 Plant Platforms

2 Stairs & Access Systems

3 Raised Walkway Systems

4 Walkway Systems

5 Acoustic & Architectural Screens



Effective Acoustic Solutions

Acoustic+ is a sound barrier that Con-form Group developed in collaboration with acoustic engineers and industry experts.

It is Australia's first and only tuneable system. It can be adjusted to suit the variety of noise levels produced on a rooftop. It has a unique 3-phase operation which absorbs-reflects-absorbs all noises.

We offer a range of 5 surface densities from 7 kilograms per square metre for lesser noises to a maximum of 31 kg per square metre.

Acoustic+ has an NRC of .75 and is the product of choice for hospitals, schools, shopping centres, aged care homes, universities, sporting facilities, medical centres, fast food outlets, service stations and office buildings.

With a combination of polyester absorptive material wrapped in durable light gauge steel, Acoustic+ is fire retardant, moisture & UV resistant.

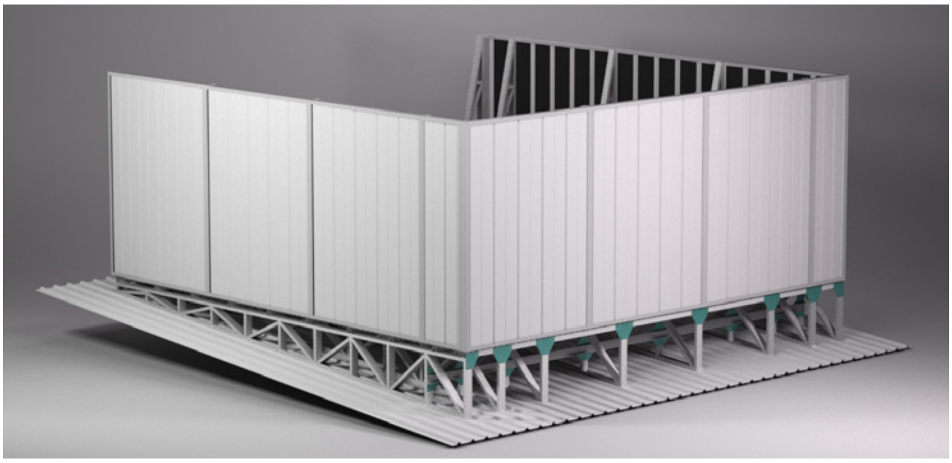
Its lightweight steel frame can easily be attached to steel and concrete roofs.

The steel is available in a range of popular Colorbond colours to complement the design of the building.

Some architects are making these screens an even more aesthetically appealing rooftop design signature by requesting acute angles, chamfers, rounded corners and a wave pattern (!).

The in-house engineers and industrial designers at Con-form Group are able to interpret those architectural concepts and our Product Development Team and Production crew convert the engineering drawings into bespoke finished products.

Acoustic+ meets Australian Standards AS/NZS1170.1, AS1170.2, ASV1170.4, AS1657, AS1664.1 and relevant clauses of the Building Code of Australia. It is certified for wind regions A, B & C.

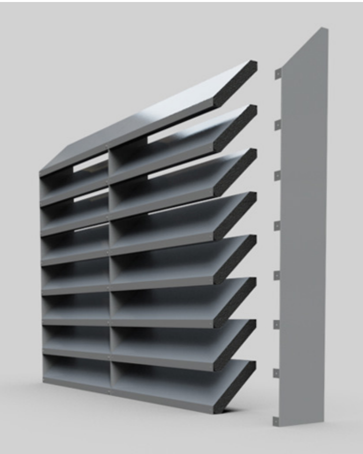


Acoustic+ Ultra Wall is the best-in-class acoustic barrier and as the name suggests it has been developed for Data Centres... the harshest noise environments.

It has an NRC rating of 1.0

Its other technical features are identical to Acoustic+.

There are times when architects will specify the need for noise suppression whilst also requiring adequate ventilation of the mechanical equipment.



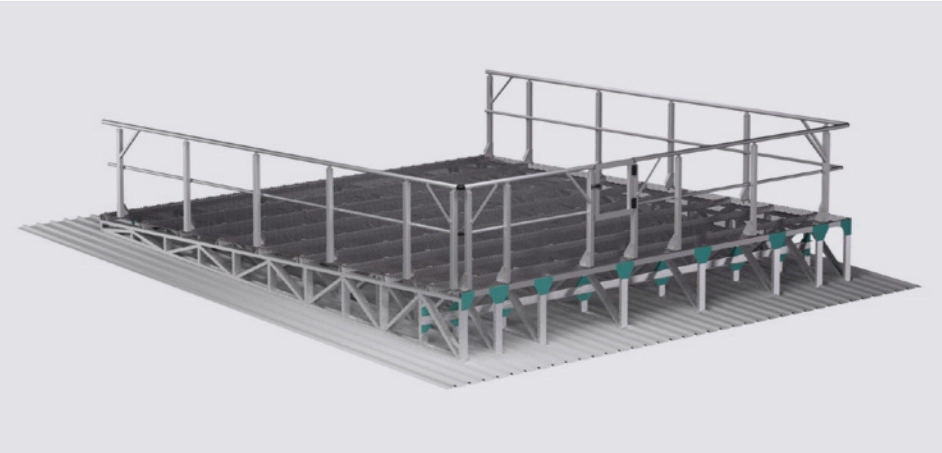

To meet this request Con-form Group developed the Acoustic+ Louvre Wall. For all rooftop environments right up to data centres.

The angled louvres contain the same polyester absorptive material as used in Acoustic+ Ultra Wall with the NRC of 1.0.

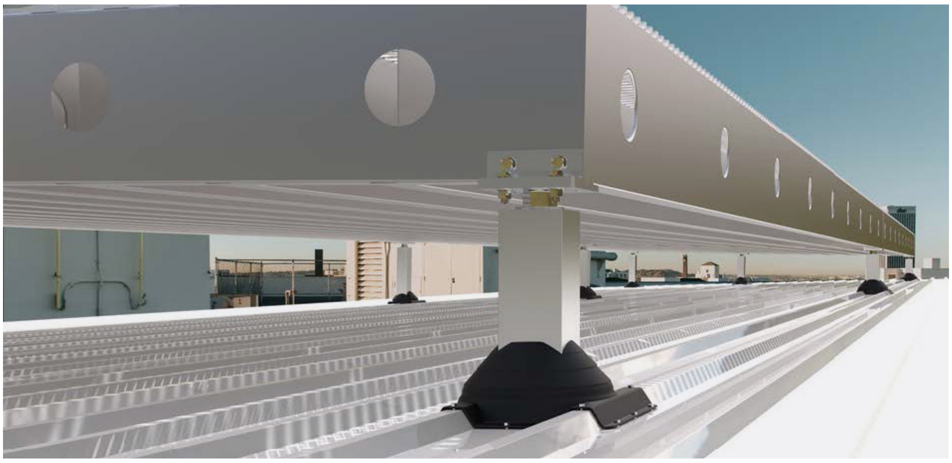
They can also be tuned to meet the variety of outbound noise levels. By mounting the panels back-to-back and creating a chevron-effect with the blades the level of captured noise is increased. The louvres can be angled either up or down (sending exhausted air skyward or towards the ground).

The Acoustic Louvre Wall is also available in popular Colorbond colours for aesthetic purposes.

All three products can be installed on metal and concrete roofs. Con-form Group offers a variety of mounting solutions to suit each project – be it a new build or retrofit.

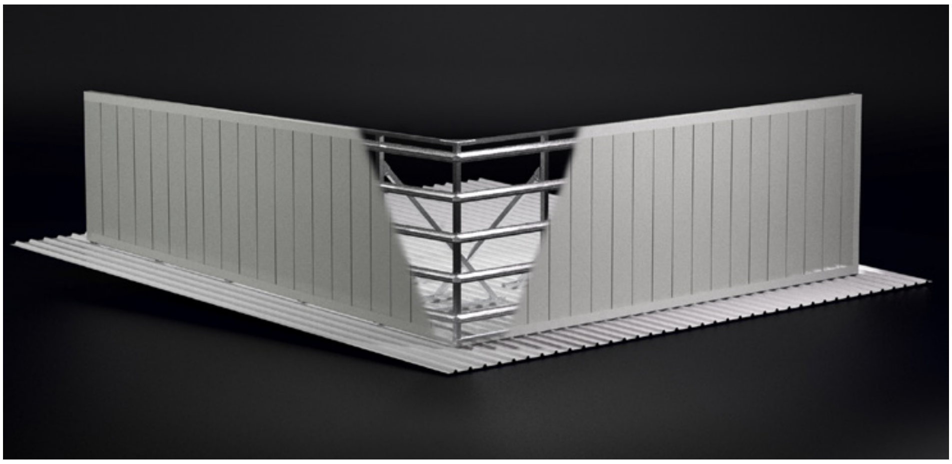


Option A: purlin-mounted platform (EasyMech MR) sits on top of a metal roof. It is penetration-free. It is used on roof pitches as acute as 20 degrees (or more). A lightweight design, it evenly distributes the weight of the screens.



Option B: rafter-mounted platform (Span+) is used when the purlins are not capable of supporting the platform. Stub columns are inserted through the metal roof with minimal access and fastened to the rafters. Like MR, this lightweight modular platform evenly distributes weight between the rafters.

Option C: concrete-mount platform (EasyMech CR) sits on top of an engineer-certified seismic (sound and shock) EasyFoot CR system. Weighing a mere 12 kilograms per square metre, it has a live load rating of 5.0 kPa (and more).



Option D: ScreentoRoof frame system for metal and concrete roofs where a platform is not required. Certified for wind regions A, B and C. Like the whole product range it is backed by Con-form Group’s 25-Year Warranty.

Conclusion

Allow us to conclude by reiterating that it is imperative for developers-building companies-architects to include an Acoustical Consultant or Con-form Group representative (engineer) as early as possible in their construction projects in order to avoid costly delays and overruns in cost.

Con-form GROUP

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MCE Manufacturing Centre of Excellence

DDC Digital Design Centre

PDC Product Development Centre

CEP Custom Engineered Product

ACP Architectural Creative Partner

D2I Design To Install

ATL Acoustic Testing Lab

Australian Owned/Operated