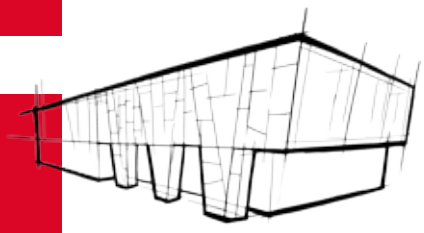
ROCKWOOL®

BUILDING INSULATION

Indoor Thermal Comfort in Buildings

Cool 'n' Comfort™ Solutions in Roofing Systems



Project
Marina Bay Sands, Singapore

Completed: 2010
Owner: Las Vegas Sands
Architect: Moshe Safdie

Introduction

Energy Efficiency in Buildings

Energy efficiency is becoming an increasingly important economic and social consideration. As the world's energy resources become increasingly limited, the need for energy efficiency in the face of rising energy costs becomes more significant.

Energy efficiency simply means using less energy than previously used in order to accomplish the same tasks, whether at home or the workplace. Using energy more efficiently may also result in paying lower energy bills, yet being able to get the same amount of work done.

In some developing countries, energy efficiency is seen as the cheapest, cleanest and safest way to contribute to reducing the country's carbon footprint.

There are many ways to apply energy efficient measures in buildings. For example, Diagram 1 explains the methods that can be used in order to achieve energy efficiency in an air conditioned building.

The pyramid in Diagram 1 shows that focusing on reducing thermal transmission will bring the biggest effect to the energy consumption of the building. This, in conjunction with other measures, can significantly reduce overall energy consumption.

There are several ways to reduce thermal transmission, such as:

- Insulating the building envelope
- Limiting thermal bridges in the construction
- Controlling air tightness and air exchange of the building envelope for better thermal comfort
- Improving thermal properties for windows and doors
- Proper planning prior to construction, taking into consideration design, orientation, and energy management

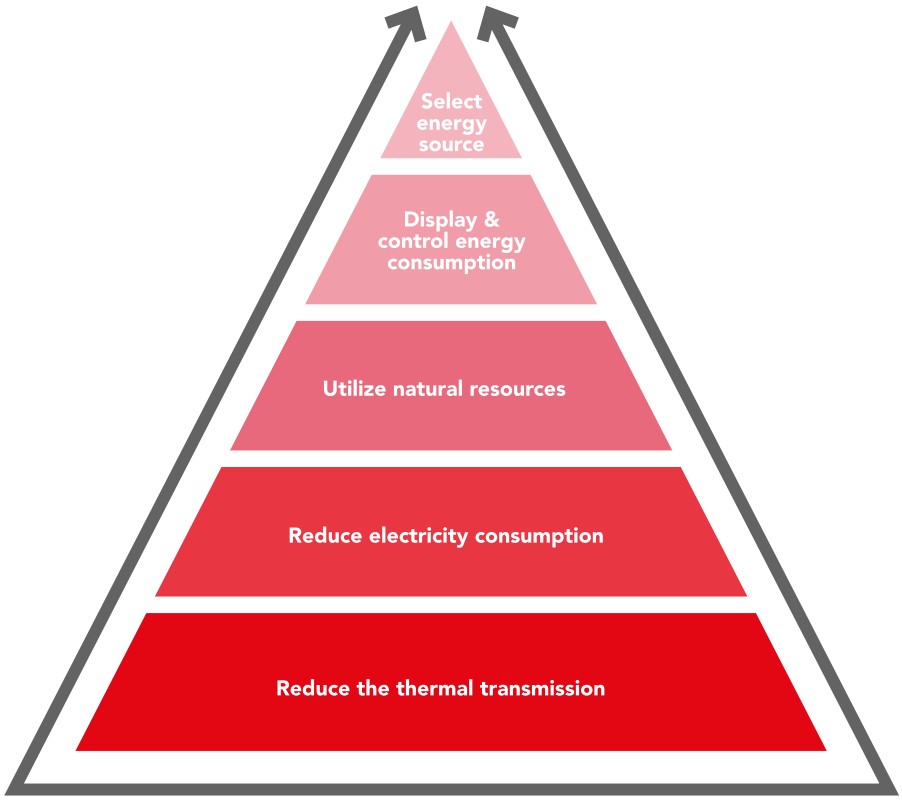


Diagram 1: Passive Energy Design Process. Source from International Energy Agency

How can Roofs be more Sustainable?

Regardless of building types, roof systems can function as a space that provides essential insulation to prevent heat gain into the building. Getting the design of the roof and the rest of the building envelope right will give the greatest benefits in terms of reduced energy use and greater sustainability.

Roof systems can be made more sustainable by taking into account the following aspects:

- Durability – making the roof structure and its components more durable while still performing to the intended criteria with regards to reducing heat gain and acoustic transmission as well as reducing the need for frequent maintenance.
- Long term reduction of heat gain - with the use of dimensionally stable insulation materials that are not affected by changes in temperature or humidity
- Recyclability – materials used in the roof system, especially the insulation materials, should be recyclable while at the same time be made from renewable raw materials.
- Long service life - far too often, building deterioration starts with a leaky roof that leads to marred interior surfaces, mold growth, and structural damage. Roof systems and components should have a long service life as designed by the architect.

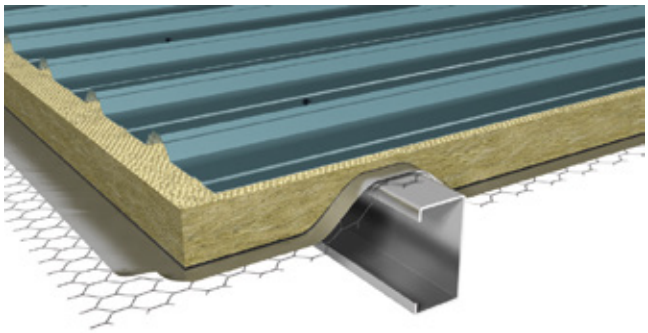
To support these aspects, highly efficient roof insulation is required to minimize building heating and cooling. Such high-performance roofing systems may also extend a building's service life.

Types of Metal Roof

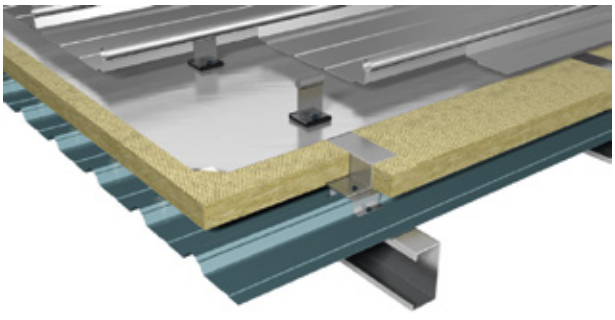
Roof systems built from metal deck profiles are commonly insulated with mineral wool. This includes various types of commercial, industrial and institutional spaces where superior thermal comfort with relatively lower costs are a concern, such as:

- Airport hangars
- Manufacturing buildings
- Warehouses
- Offices
- Sports facilities such as stadiums and gymnasiums

Insulated metal deck roofs should demonstrate the ability to withstand exposure to large differences in temperature on both the exterior and interior skins. These types of roofs have become increasingly popular over the last few years because they offer building and homeowners benefits such as being inexpensive and fairly easy to install. Profiled steel are commonly used in various types of metal deck roof constructions like the below.



Single Skin Metal Deck Roof - Corrugated or profiled metal sheet fixed directly to the purlins with or without insulation material.



Double Skin Metal Deck Roof - Corrugated or profiled top metal sheet fixed to the bottom corrugated metal sheet using a spacer system which is then fixed onto the purlin. This roof construction typically uses mineral fiber as insulation.

The Need for Insulation in Roofing Systems

A roof is a defining part of a building's look, whether it be an iconic struture, a utilitarian office or a comfortable home. Beyond that, it also provides protection from bad weather, notably rain, but also heat, wind and sunlight, and ensures a conducive and comfortable environment for the building's occupants. Roof insulation is a key component of the roof, as it improves the performance of the roof system in terms of thermal, acoustic and fire benefits, ensuring that occupants are comfortable and safe.

Roofing Material	λ-value (W/mK)
ROCKWOOL stone wool insulation	0.035-0.048
Clay/Concrete	1.6-2.0
Stainless steel	15
Steel	50
Aluminium	160
Copper	386

Good insulators

Poor insulators

Table 1: Insulating properties of various roofing materials

Affordable houses in Asia suffer from a high level of heat build-up; on sunny days roof temperatures can go up to 70°C. Without insulation the extreme heat can penetrate the building and transform it into a very uncomfortable sweatbox. Materials such as concrete tiles, clay tiles and metal deck permit the high transmission of solar radiation that induces a sauna effect, which creates an uncomfortable environment.

As more buildings are moving into metal constructions for its speed and light weight construction compared to concrete and clay, roofing specialist are adding insulations into the metal roofing system to improve the system's thermal conductivity performance, hence making it a more cost effective roofing system compared to clay or concrete roofs.

Performances of Insulation in Roof Systems

Thermal Performance

Each type of roof system is particularly affected by the different hours of air conditioning operating hours in the space immediately below the roof.

Imagine if you want to have a room temperature of 24°C, and your starting (room) temperature is 30°C, your air conditioning units would have to lower the temperature by 6°C. If the starting temperature of the room is 34°C, your air conditioning units would need to lower the temperature by 10°C. Therefore, you would have to spend much more on electricity and require even bigger air conditioners just to reduce the heat that penetrates into the building through the roof and outer walls. This is clearly illustrated in Diagram 2 and Diagram 3.

For optimum performance, the roof system should be properly insulated and constructed so that there are no significant thermal bridges or gaps. This can be achieved by using thermal pads, proper sealant and gaskets that are readily available. Attention should also be given to joint details, connection of the construction and openings, in order to limit air leakage from the building. This will provide a controlled air exchange environment that will give better thermal comfort. Proper design and construction is critical in ensuring lower energy consumption in buildings, at the same time providing a comfortable indoor climate.

Insulation is a long term investment and requires no further maintenance once the insulation has been installed. The energy savings generated during the lifetime of the building will more than cover the costs of investment.

Condensation Control

Interstitial condensation can occur if water vapour, from within the building, is able to penetrate through the metal decks and reach cold areas outside the insulation, where it may condense, usually on the outer metal sheet. If suf cient condensation occurs, it could cause problems such as corrosion of metal components and wetting of thermal insulation (severely impairing performance), and the condensate could run into the building ruining internal finishes or dripping onto equipment. Single skin metal deck roofs where the insulation and wire mesh is directly exposed to the hot or cold air on the underside of the roof, is particularly susceptible to condensation.

The moisture content of the internal environment should be assessed and controlled by providing the correct levels of ventilation or by air conditioning. It should be recognised that there will be some degree of moisture load in almost all buildings, therefore the design of the roof structure should:

- Prevent water vapour reaching the cold areas of the roof structure, by including an impermeable vapour control layer on the warm side of the insulation; and
- Provide means of escape for any water vapour that does penetrate the structure.

To minimize the potential for interstitial condensation in double metal skin construction, the most critical part of the construction is the vapour control layer. This is used to minimize the amount of moisture vapour which can enter the construction by diffusion and air leakage. It must be positioned on the warm side of the insulation. The vapour control layer can be made by carefully sealing the pro led metal liner or by providing a separate membrane on the metal sheet. In either case it is essential that the vapour control layer is continuous throughout the roof and all laps are sealed, including at abutments, roof lights, penetrations, gutters, ridges and other parts of the roof.

Diagram 2:
Room without insulation requires 10°C cooling

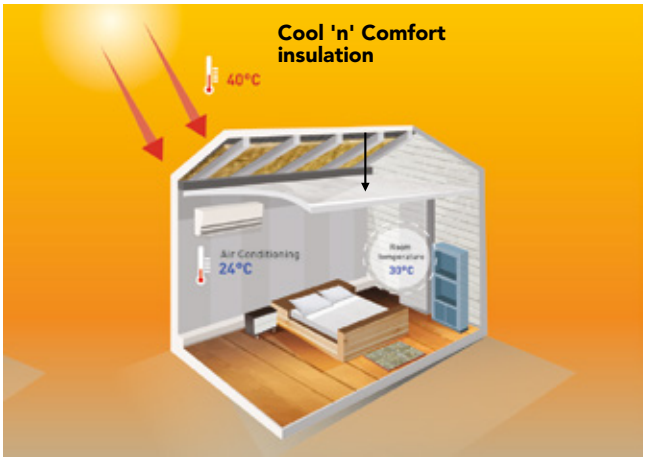


Diagram 3:
Room with Cool 'n' Comfort insulation requires 6°C cooling

Acoustic Performance

Noise is defined as unwanted sound and it is therefore essential that the control of noise pollution is addressed from the earliest stage in the design process. Excessive exposure to noise can cause issues such as:

- Inability to concentrate and perform basic activities
- Annoyance that triggers stress and inability to focus
- Disruption of rest or sleep; signi cantly reducing the quality of life

Ambient noise is the result of noises which emanates from various sources. Continuous or excessively loud ambient noise can have a detrimental effect on a person's quality of life, therefore, acoustic insulation is an important consideration in buildings, especially roof constructions.

The external roof represents a large proportion of a building's surface area, and therefore its acoustic performance plays a significant role in establishing an acceptable environment within the rooms below. Unfortunately, the acoustic performance of a roof often gets overlooked or is addressed too late in the design process to be effective and as a consequence the solution provided is seldom adequate.

The damping and absorption effect of noise from materials are illustrated in Diagram 4 and 5.

A guitar is filled with sand for the purpose of reducing the vibration that travels into the sound box and the re ection that takes place in the sound box. This example shows that sound can be reduced by damping the vibrations.

Putting the example into the context of building elements such as roof systems, especially lightweight metal deck roofs which are popular in Asian countries, it is important to control and reduce vibrations within the system itself so that a suitable, comfortable environment is preserved.

The lightweight metal deck roofs provide good value in durability, less maintenance and aesthetic. Whilst being popular, there are very few rules governing the acoustical performances of these roofs, and they are often not enforced even when established guidelines exist.

Metal deck roofs are typically formed by thin sheets of rolled- steel cladding, these roofs often amplify rain impact noise. The acoustic performance requirements of metal deck roofs will be specifically influenced by the building's location together with its layout and overall design. Building design needs to provide for control and reduction of noise break-outs for building types such as hypermarkets, stadium, warehouses and other similar environments.

If the roof structure is required to perform as a sound reduction from external sources, then the mass of the structural deck and individual roof layers are of great importance in determining the acoustic performance.

Lightweight metal decks incorporating single skin pro les can provide a good level of sound reduction. They can be further enhanced through the use of additional insulation layers in combination with additional mass layers.

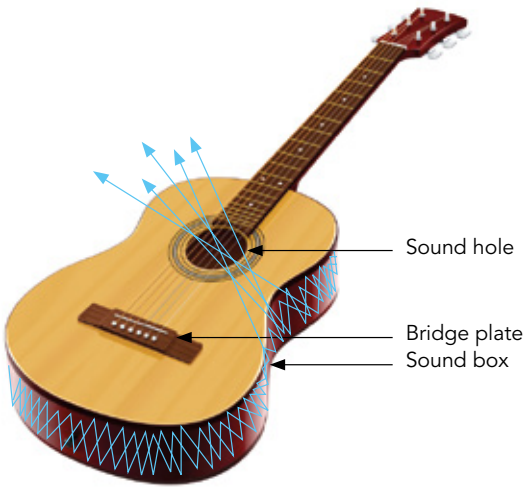


Diagram 4:
Sound box of a guitar showing how sound travels and gets reflected to create sound

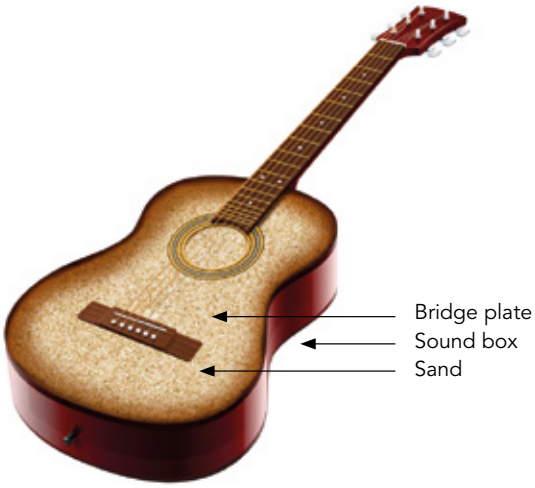


Diagram 5:
Sound box filled with sand to dampen sound

Rain Noise and Control

Metal deck roof systems are commonly used in commercial and industrial buildings, educational institutions, stadiums and auditoriums because of the need for bigger span of clear undisrupted spaces. Activities in these spaces are affected by the noise generated by the intensity of the rain. Noise levels exceeding the recommended ambient noise can cause annoyance and affect daily activities.
Typically, metal roof panels are made of either steel or aluminum. The thickness of the panels varies from 0.46mm to 2.0mm. When it rains, the thin metal panels will resonate and generate a high level of noise. According to the publication Building Bulletin #93, London (2004), the level of noise produced by rain impact on metal deck roofs can reach 70dB. Some studies compared this noise to aircraft or trafic noise which is usually around 65dB. The noise and vibration are transmitted through the roof and radiated as structural air- borne noise into a building. As such, rain impact noise should not be underestimated nor neglected.

One of the most cost-effective solution is to apply sound dampening materials onto the metal panels. Roof insulation such as stone wool absorbs the vibration energy and therefore reduce the rain impact noise of the thin metal panels.

Building designers' objective is to reduce the rain impact noise on metal deck roof systems by

- Putting in additional layers of dense materials such as insulation
- Adding board panels to the basic metal roofing system to increase transmission loss properties

Fire Protection

The manner in which all elements of building construction perform in the event of a fire is of prime concern to the designer, the occupant, the building owner and the building insurance company. Pro led metal deck roof constructions must therefore conform to specific requirements by the local fire rescue department. The main requirements are to:

- provide a safe means of escape for the building occupants by preventing internal fire spread.
- prevent the spread of fire to neighbouring properties
- prevent an external fire from setting fire to the building
- provide access for the fire brigade

Generally metal roof cladding has to limit the spread of fire on its internal liner face, prevent the spread of fire through any cavity, and resist the spread and penetration of fire on its external facing side.

However, in the event of a fire, it makes sense to use construction materials and roofing components that do not burn in the first place. In a fire, heat and hot gasses travel upwards and to the ceiling boards. Insulation below the roofing will usually be the first component of a building construction to be exposed. If a combustible material is used, fire can quickly spread throughout the material and in minutes, the entire roofing system will collapse.

With the typically wide area coverage of a roof, this can prove disastrous for buildings, resulting in severe damage and perhaps even the loss of life. Hence, the use of non-combustible materials even in non- re rated systems will mean the difference between protecting or risking lives and assets. Non-combustible materials like stone wool is widely used in both fire rated and non-fire rated systems because of its excellent and proven fire resistant properties.

ROCKWOOL stone wool insulation passed the relevant tests relating to the performance of insulation material to the reaction to fire, namely non-combustibility, flame spread and toxic smoke development.

Test Standard	Description
BS 476 Part 6	Fire tests on building materials and structures – Method of test for fire propagation for products
BS 476 Part 7	Fire tests on building materials and structures – Method of test to determine the classification of the surface spread of flame of products
En 13501-1	Fire classification on construction products and building elements – Classification using data from reaction to fire tests

Table 2: Fire performance tests

Water Repellency

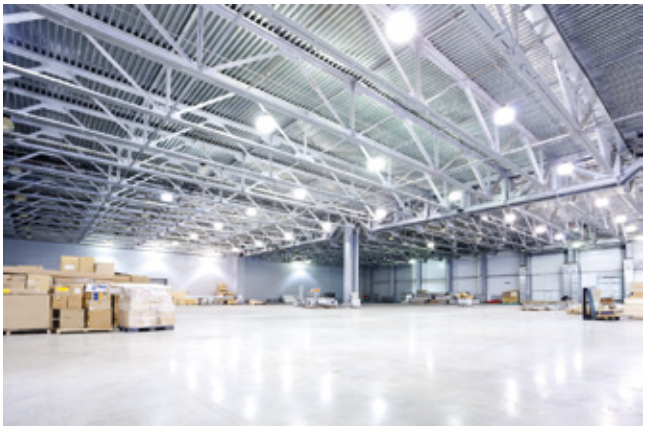
The sudden downpours that occurs in tropical climates can become a major problem if installation work is being carried out on the roof of a building. Not only is there a high chance that the materials used will be damaged or wasted but the removal and replacement cost in lost man hours cannot be underestimated. The disruption can also result in both lengthy delays to a project as well increased in materials cost.

It is important for roof insulation to have a low water absorption rate so that it does not contain excessive moisture or water that may cause risks or damage to the building. For example, when building elements such as the roof system suffers from a leakage, the insulation material in the roof system will be directly exposed to water. If the roof insulation being used has a high water absorption rate, the excessive exposure to moisture may cause fasteners, fixtures or the metal structure of the roofing system to corrode over time. This can lead to high repair and maintenance costs. What makes such situations worse is that leaking roof systems often remain unnoticed, and over time, may even be at risk of collapse due to the damage from the corrosion. Therefore, it is important that the insulation materials used do not absorb water, and also be able to repel water from the roof effectively, ensuring a robust and safe structure.

Recommended Solutions for Roof Systems

Airport	
Type	Double skin metal roof
Maximum sound Level, L_{Aeq}	55 dBA
STL rating	STC 70
U-value	0.6 W/m^{2}k

Hypermarket	
Type	Single or Double skin metal roof
Maximum sound Level, L_{Aeq}	55 dBA
STL rating	STC 55
U-value	0.6 W/m^{2}k



Warehouse	
Type	Single or Double skin metal roof
Maximum sound Level, L_{Aeq}	60 dBA
STL rating	STC 50
U-value	0.6 W/m^{2}k

Food court or Dining area	
Type	Single or Double skin metal roof
Maximum sound Level, L_{Aeq}	55 dBA
STL rating	STC 55
U-value	0.4 W/m^{2}k

Enclosed car park	
Type	Single skin metal roof
Maximum sound Level, L_{Aeq}	65 dBA
STL rating	STC 45
U-value	0.4 W/m^{2}k

Manufacturing space - Light Assembly	
Type	Single or Double skin metal roof
Maximum sound Level, L_{Aeq}	70 dBA
STL rating	STC 45
U-value	0.4 W/m^{2}k

Stadium or Sports centre	
Type	Double skin metal roof
Maximum sound Level, L_{Aeq}	65 dBA
STL rating	STC 45
U-value	0.4 W/m^{2}k

Auditorium or Theatres	
Type	Double skin metal roof
Maximum sound Level, L_{Aeq}	40 dBA
STL rating	STC 70
U-value	0.6 W/m^{2}k

Disclaimer: The number in the table are based on applicable standard and best practice.

ROCKWOOL Solutions with Cool 'n' Comfort

In order to meet the requirement of metal deck roof systems, the insulation used must possess the following characteristics to improve the performance and make the roofs more durable. ROCKWOOL Asia offers a new range of products using the Cool 'n' Comfort RL series in rolled form as well as the Cool 'n' Comfort SL series in pre-formed slabs. In a nutshell, the roof insulation Cool 'n' Comfort RL and SL series are equipped with the following attributes in Table 3.

Important criteria for roof insulation	Characteristics of Cool 'n' Comfort
Dimensional Stability	■ Stability of R-value performance in different climates (temperature and humidity)
Uniformity of thickness	■ Thickness are made strictly through internal control on thickness tolerances
Convenient, equal size panels	■ Available in roll and slab form ■ Supply as it is with standard sizes and dimensions
Compatibility with other elements in the roof system	■ Water repellent ■ Vapour permeable allowing vapour to pass through ■ Lower the risks of condensation
Warping/cupping under field performance	■ Long lasting with no deformation such as warping or sagging
Fire resistence/combustibility	■ Non-combustible ■ Tested to EN13501-1, achieve Euroclass A1 ■ Melting point above 1000°C
Acoustical properties	■ Noise reduction criteria, NRC = 1.0 ■ Essential in absorbing sound energy reducing noise
Sustainability (manufacturing, field performance and beyond)	■ Products are tested and listed under the Singapore Green Building Product Listing scheme (SGBPLS) ■ Environmental Product Declaration (EPD) available

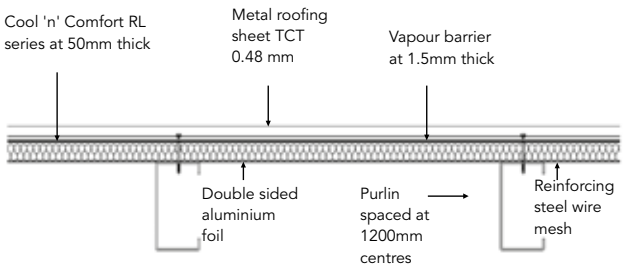
Table 3: The attributes of Cool 'n' Comfort for roof insulation

In order to achieve the recommended acoustic performance of the metal roof system based on its usages, following are some of the roof con gurations with their respective performances in sound attenuation which is expressed as Sound Transmission Class (STC) as well as the rain impact noise that is expressed in A-weight intensity, L subscript (IA).

The rain impact noise tests are in accordance with ISO140-18:2006 – 'Laboratory Measurement of Sound Generated by Rainfall on Building Elements' using ROCKWOOL Cool 'n' Comfort series installed in roof construction combinations in single and double skin metal deck roof systems. To re ect the climate in Asia, the rain impact noise level were tested in the rainfall intensity of normal rain at 40mm/hour and a tropical thunderstorm at the intensity of 300mm/hour.

The selection of system is important infinding the suitable system for the application. For further information, please get in touch with your local ROCKWOOL representatives.

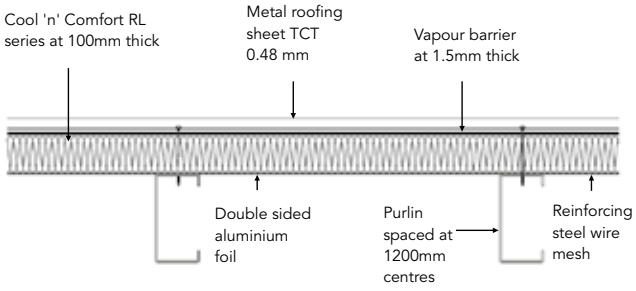
Single skin metal deck roof system:



System 1

Single skin metal deck roof using ROCKWOOL Cool 'n' Comfort RL series at 50mm thick fixed underside of metal roofing sheet of TCT 0.48mm, complete with vapour barrier of 1.5mm and double sided aluminum foil, securely fixed onto roof purlins spaced at 1200mm centres.

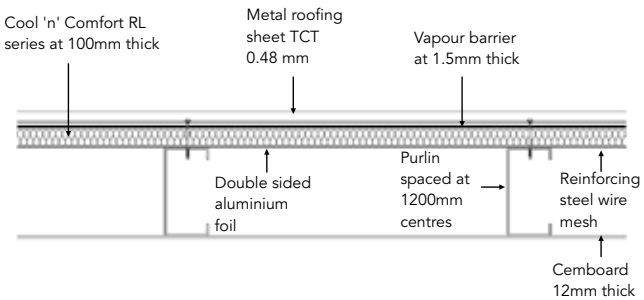
Rainfall Intensity	Rain Impact (A-weighted Intensity), L_{IA}	STC
40mm/hour	50.6	33
300mm/hour	57.4	



System 2

Single skin metal deck roof using ROCKWOOL Cool 'n' Comfort RL series at 100mm thick fixed underside of metal roofing sheet of TCT 0.48mm, complete with vapour barrier of 1.5mm and double sided aluminum foil, securely fixed onto roof purlins spaced at 1200mm centres.

Rainfall Intensity	Rain Impact (A-weighted Intensity), L_{IA}	STC
40mm/hour	49.1	38
300mm/hour	55.6	



System 3

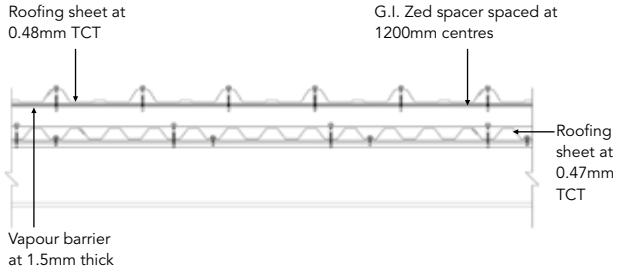
Single skin metal deck roof using ROCKWOOL Cool 'n' Comfort RL series at 50mm thick fixed underside of metal roofing sheet of TCT 0.48mm, complete with vapour barrier of 1.5mm and double sided aluminum foil, securely fixed onto roof purlins spaced at 1200mm centres. One layer of 12mm cemboard securely fixed to the underside of purlin.

Rainfall Intensity	Rain Impact (A-weighted Intensity), L_{IA}	STC
40mm/hour	37.9	49
300mm/hour	43.9	

** Sizes and dimension of metal roofing sheet, vapour barrier and aluminium foil may vary according to different manufacturers.*

** For variation on component dimension and spacing, kindly contact your local ROCKWOOL representatives for expected acoustic performances.*

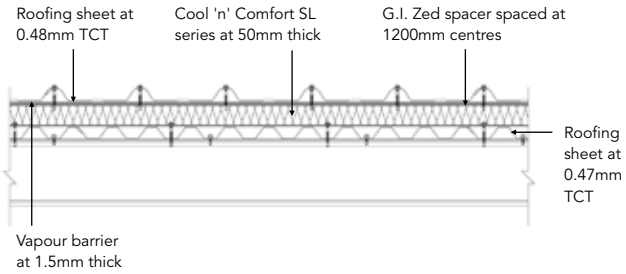
Double skin metal deck roof system:



System 1

Double skin metal deck roof with no insulation fixed underside of metal roofing sheet of TCT 0.48mm fixed onto zed-spacer spaced at 1200mm centres and bottom roofing sheet at TCT 0.47mm complete with vapour barrier of 1.5mm, securely fixed onto roof purlins spaced at 1200mm centres.

Rainfall Intensity	Rain Impact (A-weighted Intensity), L_{IA}	STC
40mm/hour	58.6	30
300mm/hour	62.0	



System 2

Double skin metal deck roof with ROCKWOOL Cool 'n' Comfort SL series at 50mm thick fixed underside of metal roofing sheet of TCT 0.48mm fixed onto zed-spacer spaced at 1200mm centres and bottom roofing sheet at TCT 0.47mm complete with vapour barrier of 1.5mm, securely fixed onto roof purlins spaced at 1200mm centres.

Rainfall Intensity	Rain Impact (A-weighted Intensity), L_{IA}	STC
40mm/hour	54.0	38
300mm/hour	57.8	

Why Cool 'n' Comfort?

With concerns growing about both the environmental impact and rising cost of energy usage, many home and building owners are looking at ways to ensure that their monthly energy bills do not spiral out of control. As the average consumer grows more savvy in terms of energy ef ciency, an increasing number will be aware of the importance of properly insulated buildings and will begin to include it on their priority list when looking to buy or build. This consumer pressure for more sustainable and environmentally friendly development has already lead to initiatives by professional bodies such the SGBC's Green Mark (Singapore) and LEEDS.

At ROCKWOOL Asia, we understand these needs, which is why we have developed what we believe to be the best product of its kind on the market right now. Cool 'n' Comfort ful lls these needs in every way with its excellent ability to save energy, reduce noise, repel water and more.

Project References

1 Suvarnabhumi Airport, Bangkok (Thailand)
2 Cheras Rehabilitation Hospital, Kuala Lumpur (Malaysia)
3 Cochin International Airport (India)
4 Sports Hub (Singapore)

800 118 - 09 / 20_V4 (EN)

*Note: EUCEB only applicable for products produced in India & Malaysian factories

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