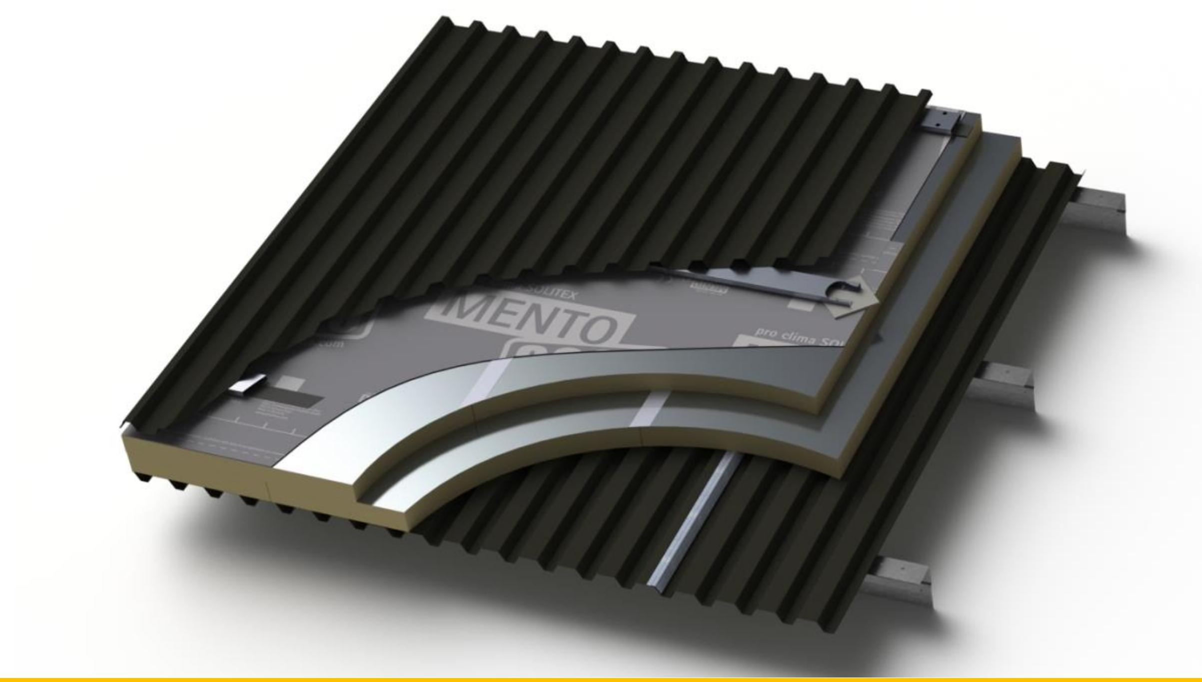


E3 Compliance Report

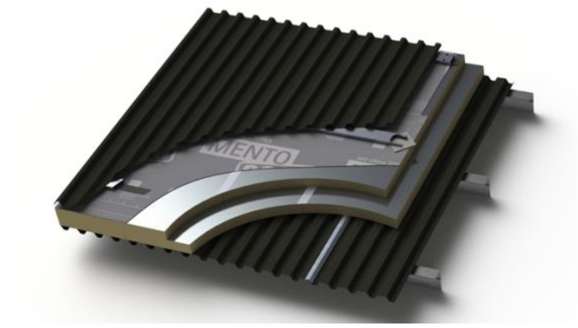
Date	October 14, 2024
Project Number	J20035
Client	MetalCraft Roofing

Met-Therm™ and Espan-Therm™ Warm Roof System

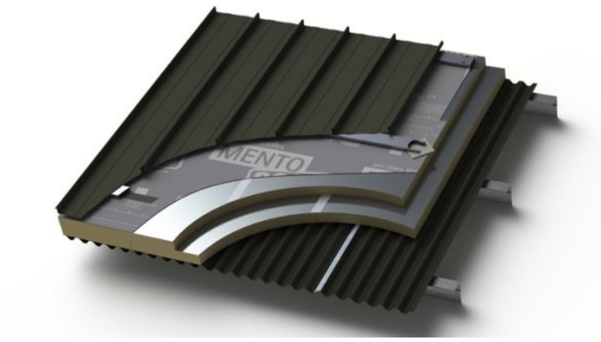
BEO
BUILDING ENVELOPE OPTIMISATION

executive summary

The roof system evaluated is the Met-Therm and Espan- Therm warm roof, designed for use in all climate zones of New Zealand. It includes layers of PIR insulation with vapor barriers and a roof underlay. The system is engineered to manage moisture while maintaining thermal efficiency across varying environmental conditions.



Metcon 7



Espan 340

Our analysis focused on evaluating the moisture performance of the roof system, considering worst-case scenarios, including minimal ventilation, internal moisture loads, roof pitch, roof orientation, and material properties. Calculations were performed using both 2D isothermal and hygrothermal modeling, alongside evaluations of installation factors such as air gaps, vapor barrier integrity, and potential errors during construction.

Findings

Our findings demonstrate that the Met-Therm system performs robustly across various scenarios, with no critical moisture accumulation identified under normal use. Key results include:

1. Roof Orientation: While roof orientation becomes more significant with increased pitch, no critical moisture buildup was found.
2. Internal Moisture Loads: Increased humidity levels inside the building did not negatively affect the roof’s moisture management capabilities.
3. Vapor Barrier: Removal of the foil face on the PIR insulation led to slightly elevated humidity in the roof underlay, but no critical moisture accumulation. Ensuring a correctly installed vapor barrier at the steel liner level is crucial.
4. Air Gaps: A small 5mm air gap between insulation boards was found to have no significant impact on the temperature or humidity performance and can be considered negligible.
5. Ventilation: Low or zero ventilation was assumed in many scenarios. While proper ventilation improves system performance, it is not always critical for compliance in worst-case conditions.

Additional Considerations

6. Staggering of Double Layers: While staggering the two layers of PIR insulation helps limit the risk of thermal bridging and ensures a tighter seal at joint areas, it was found to be a negligible element in overall system performance.

7. Taping the Foil Face of PIR: In cases where water vapor migrates into PIR layer 1, this poses less risk than moisture migrating into the outermost layer (PIR layer 2). This is due to the higher dew point risk at adjacent surface temperatures in layer 2. Taping the outer layer of the first PIR layer provides a secondary defense against moisture should the internal vapor barrier fail. However, since the PIR is largely impermeable across its surface, the risk areas remain concentrated at joint areas between boards.

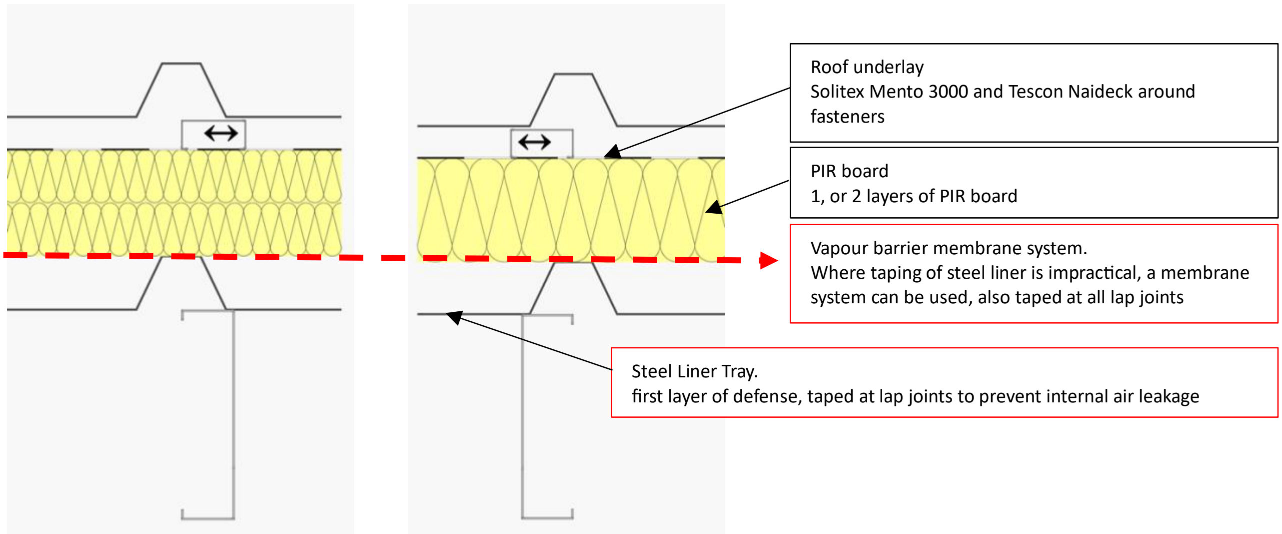
Critical Elements for Performance

To ensure the roof performs as designed, it is critical to:

1. Ensure proper installation of the vapor barrier at the steel liner level to prevent air infiltration.
2. Avoid significant air infiltration into the PIR layers, which can lead to problematic moisture accumulation.
3. Maintain adequate ventilation in cases where moisture loads are higher than anticipated.

Meanwhile, **negligible** elements that do not affect performance include:

1. Small air gaps between insulation boards (≤ 5mm).
2. The staggering of double PIR layers, which, while beneficial, does not critically impact performance.
3. Taping the foil face of the first PIR layer, which adds a secondary moisture defense but is not proven critical under normal conditions.



Fasteners

Fixings, particularly metal fasteners, can create cold spots in the roof system, increasing the risk of surface condensation around these areas. This condensation can compromise both thermal performance and material integrity over time. The use of Pro Clima Tescon Naideck tape around fixings can effectively manage surface condensation by sealing these potential weak points. Naideck tape is specifically designed to create airtight and watertight seals around penetrations, reducing the risk of moisture ingress at fasteners and helping maintain the overall performance of the roof system.

at a glance

The Roof System

The Metalcraft Met-Therm roof system shown in the diagrams is a built-up warm roofing design featuring PIR (Polyisocyanurate) board insulation. This system includes several components aimed at ensuring both thermal efficiency and compliance with H1 regulations.

Metalcraft offers two core types for the roof system based on fire protection needs, and these are available in various thicknesses for compliance with different H1/AS1 and H1/AS2 standards across climate zones, in particular:

- CNZ PIR Panels as well as IKO Enertherm ALU:
  - R-value of R7.0 is achieved using two layers of 75mm PIR board
  - R5.6 to R7.0, using 50mm PIR boards in lower R-value zones and 75mm boards in higher R-value zones.

- MetecnoTHERM PIR Panels
  - R4.5 to R7.2 using 50mm and 80mm PIR boards in various configurations.

This system provides flexibility in terms of thermal insulation thickness based on project requirements and compliance standards.

Purpose

This reporting format is designed to provide the reader with a comprehensive understanding of how the ASHRAE160 and DIN ISO4108 can be used as an alternative solution for compliance with New Zealand Building Code Clause E3 (Internal Moisture).

Background information

The system is being introduced across all climate zones of New Zealand and has been requested for review under Clause E3, internal moisture.

We verify the compliance using hygrothermal, or Isothermal analysis to determine the dynamic water vapour movements within the materials and whether suffiecient moisture is present to explain the wetting insulation.

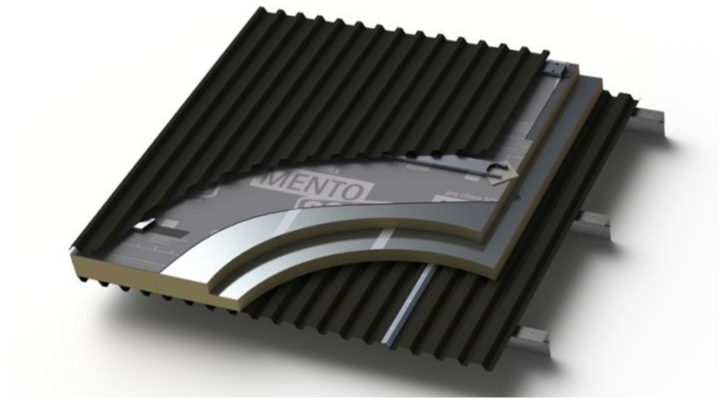
To evaluate the potential risks for condensation using WUFI analysis we propose the following steps:

1. Climate-Specific Assessment: We will model the system in varying climates to reflect the different environmental conditions experienced in each region. This includes assessing temperature ranges, humidity levels, and seasonal variations that may impact moisture movement.
2. Material Properties and substrate sensitivity: The analysis will consider the properties of the PIR insulation, membrane layers, and other key materials in the roof assembly. This helps us understand how these materials manage water vapor transmission and the insulation's ability to resist moisture build-up.

3. Roof Pitch and Color: The pitch and color of the roof can significantly affect its thermal and moisture performance. Darker roofs may absorb more heat, increasing the drying potential, while roof pitch influences water runoff and ventilation efficiency.
4. Roof Ventilation Capacity: We'll evaluate the roof's span and cavity height, which affects airflow and ventilation performance. Proper ventilation is critical to preventing condensation buildup, particularly in warm roof systems.
5. Roof Orientation: By considering the orientation of the roof, we can account for solar gain and prevailing wind patterns that influence moisture transport and drying rates.
6. Internal Moisture Loads: Varying internal moisture loads will be factored into the analysis, particularly in regions with higher occupancy, cooking, and showering rates. This will help determine whether additional ventilation or moisture control measures are required to manage condensation risks.

elements and assemblies- analysis

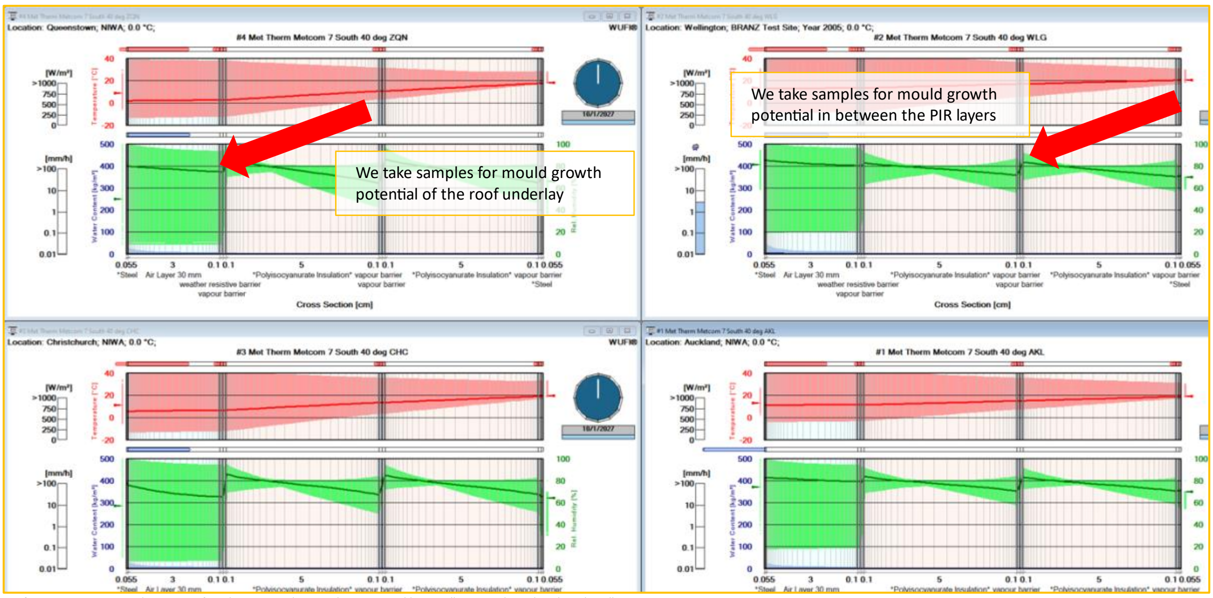
Roof



From exterior to interior:

- Metal Roof, profile 0.55mm
- 30mm ventilated cavity
- Proclima Solitex Mento 3000
- 2 x 50mm, or 1 x 100mm foil faced PIR
- Metal Roof, profile 0.55mm
- Roof Purlins/Structure, open to the interior

Climate-Specific Assessment



Roof section in WUFI, 40 degrees roof pitch orientated to South across Aucklan, Wellington, Christchurch and Wellington

Our analysis, conducted across four distinct climate zones in New Zealand—Auckland, Wellington, Christchurch, and Queenstown—has shown that the Met-Therm system performs consistently across these regions.

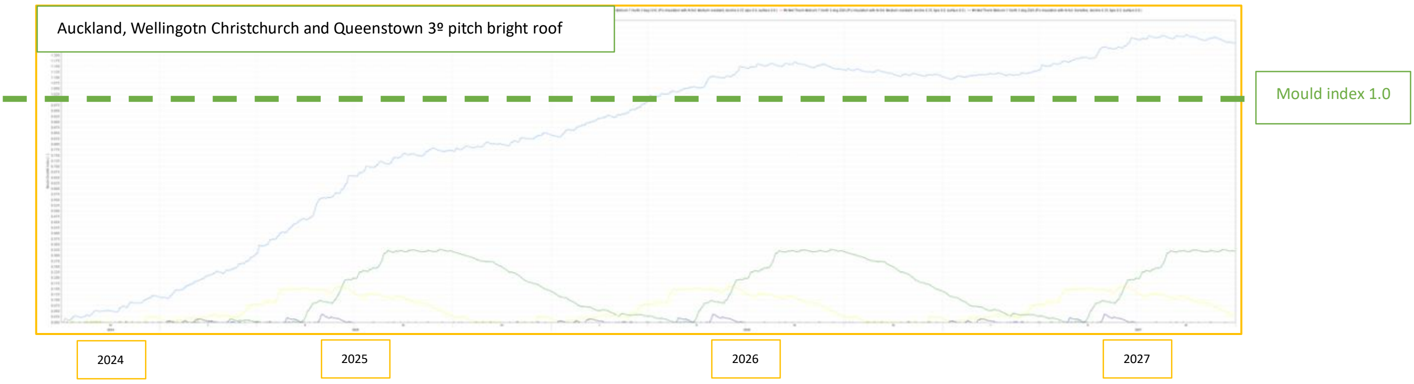
The typical findings indicate that while there is an elevated level of humidity where the vapor barriers are positioned, this is expected and reflects normal diurnal and seasonal fluctuations. The vapor barriers act as intended, effectively controlling moisture flow without resulting in any long-term issues.

Crucially, the analysis revealed no accumulation of water or condensate within the roof assembly, particularly between the two layers of PIR insulation or on the roof underlay above the PIR layers. This confirms that the system is well-suited for use in varying climatic conditions, providing robust thermal performance without compromising moisture control.

Material Properties and substrate sensitivity

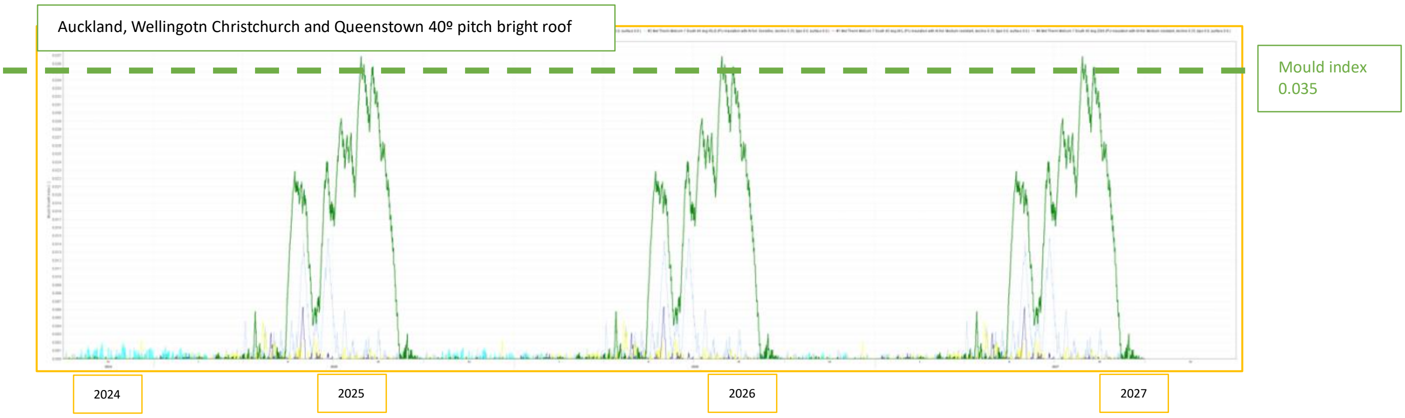
Our detailed analysis of the Met-Therm system's material properties revealed no problematic accumulation of condensation or water beyond expected fluctuations. The materials, including the PIR insulation and associated membranes, function as intended under varying moisture conditions.
In the post-processing review, we closely examined the boundary layers, particularly the vapor barrier and roof underlay. The analysis demonstrated that while there are predictable diurnal and seasonal spikes in moisture levels, the system's substrate is resilient enough to handle these fluctuations without risk of mold growth.
The moisture sensitivity of the materials is low, meaning that even during periods of higher humidity, the substrates are not conducive to conditions that would foster mold formation. This further reinforces the suitability of the Met-Therm system in ensuring moisture control and maintaining building health over the long term.

3 degree roof pitch



In our analysis, the mold index graph showing an increase in mold growth over time represents a sensitive to very sensitive substrate for mold formation. However, it's important to clarify that this scenario does not reflect the actual materials used in the Met-Therm system.
The materials employed in the roof assembly are rated as having at least medium resistance to mold growth, which means they are much less susceptible to mold formation than what is shown in the sensitive substrate model.
Therefore, while the graph demonstrates a worst-case scenario for highly sensitive substrates, the real-world performance of the Met-Therm system ensures that mold growth is unlikely due to the materials' inherent resistance, even under elevated moisture conditions.

40 degree roof pitch (South Orientation)



In the second graph, we analyzed the performance of the roof at a 40-degree pitch, oriented to the South—a worst-case scenario for moisture exposure. Using the correct minimum resistance values for the materials, the results show that despite the seasonal spikes in moisture, the mold index remains well within acceptable limits.
This demonstrates that even under less favorable conditions, the Met-Therm system is capable of maintaining moisture control without exceeding critical thresholds for mold growth. The materials' adequate resistance, combined with proper design and orientation, ensures long-term durability and protection against mold, even in the harshest conditions.

Roof Pitch and Color

Our analysis of roof pitches at 3, 10, 20, and 40 degrees shows consistent performance across all climate regions in New Zealand. Lower pitched roofs, such as those at 3 and 10 degrees, exhibit minimal variance in moisture behavior and overall performance regardless of orientation. These low-slope roofs are more affected by surface colour or shading because their shallow angle reduces the capacity to ventilation and drainage.
As we increase the pitch to 20 and 40 degrees, the roof becomes more sensitive to solar orientation. At these steeper angles, the roof's ability to shed water improves, but it also becomes more susceptible to solar gain, or the lack thereof. This leads to more significant seasonal fluctuations in temperature, which can influence the moisture control dynamics within the roof assembly. Despite these variations, our evaluations confirmed that even at higher pitches, the Met-Therm system performs effectively without exceeding moisture or mold thresholds.

Darker roofs absorb more solar radiation, increasing the surface temperature and allowing for improved evaporation and air movement. Lighter-colored roofs, on the other hand, reflect more sunlight, resulting in lower surface temperatures and reduced drying and ventilation.

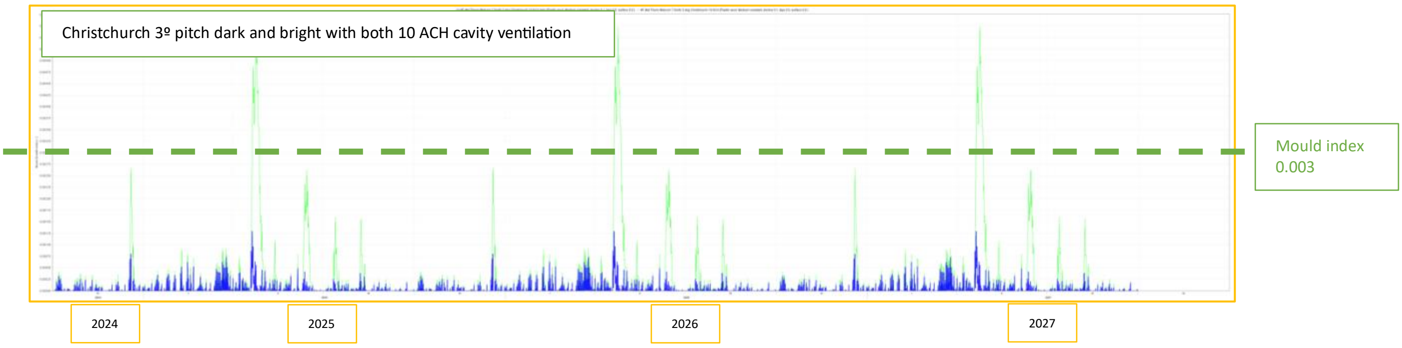
Roof Ventilation Capacity

In this section, we will evaluate the impact of ventilation in the outer roof cavity and its contribution to moisture management in the roof assembly. Typically, we assume very low to zero ventilation capacity in our calculations due to the inherent unpredictability of how the system will be applied in real-world conditions. As discussed earlier, scenarios such as low-angle roofs, bright surfaces, long spans, low cavity heights, and overshadowed environments often result in minimal natural ventilation. Consequently, ventilation, or lack thereof can be largely overlooked in these cases.

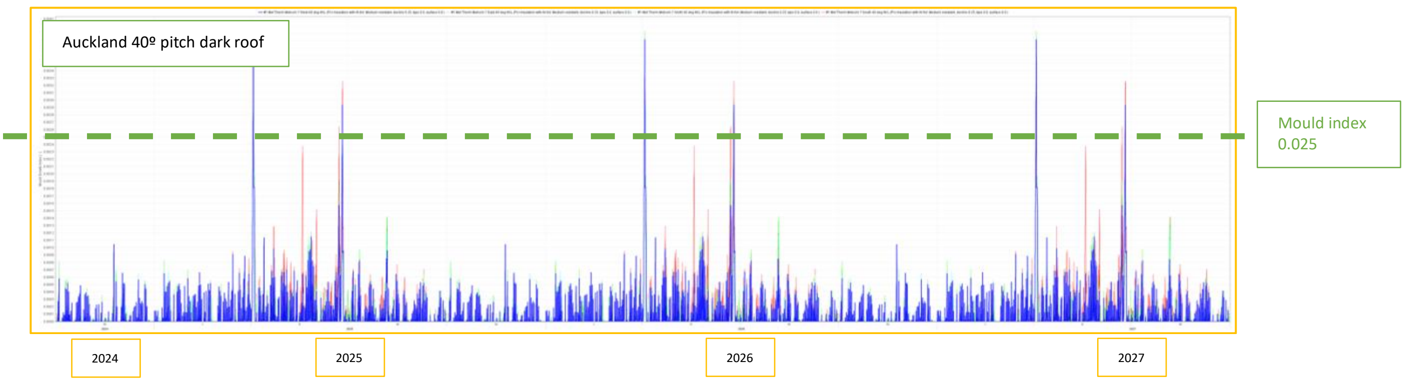
Introducing sufficient ventilation into the roof cavity can significantly improve the assembly's drying potential, especially when dealing with moisture loads from condensation or external humidity. In most applications, ensuring adequate airflow will result in a robust system that works well under various conditions. However, our goal is to show compliance even under worst-case scenarios, where ventilation is severely limited or entirely absent.

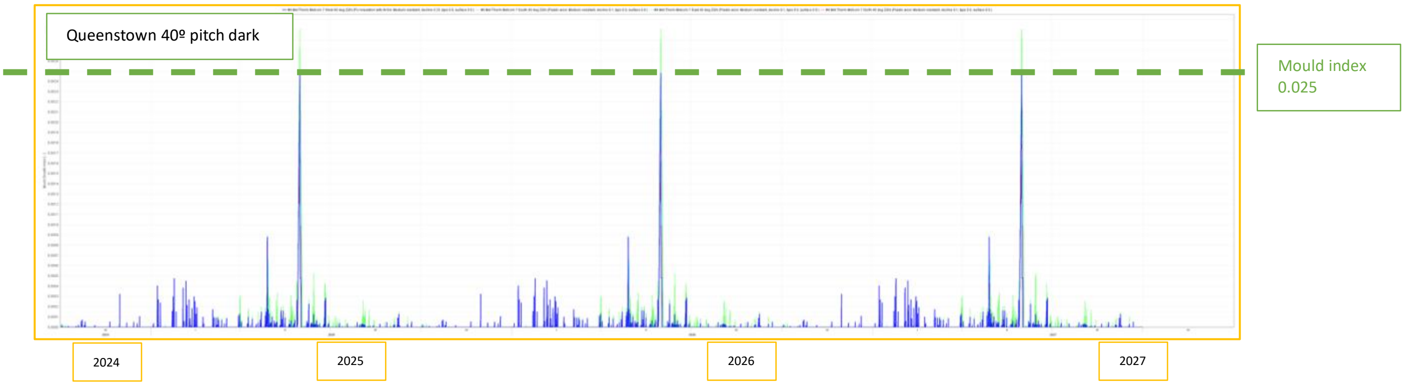
By taking this conservative approach, we aim to provide a thorough evaluation that guarantees moisture control and system performance even when optimal ventilation cannot be achieved.

In our calculations we looked at increasing the ventilation rates up to 10 Air Changes and found that the roof performance did not significantly change. In fact, changing the surface colour had a larger impact than added ventilation.



Roof Orientation



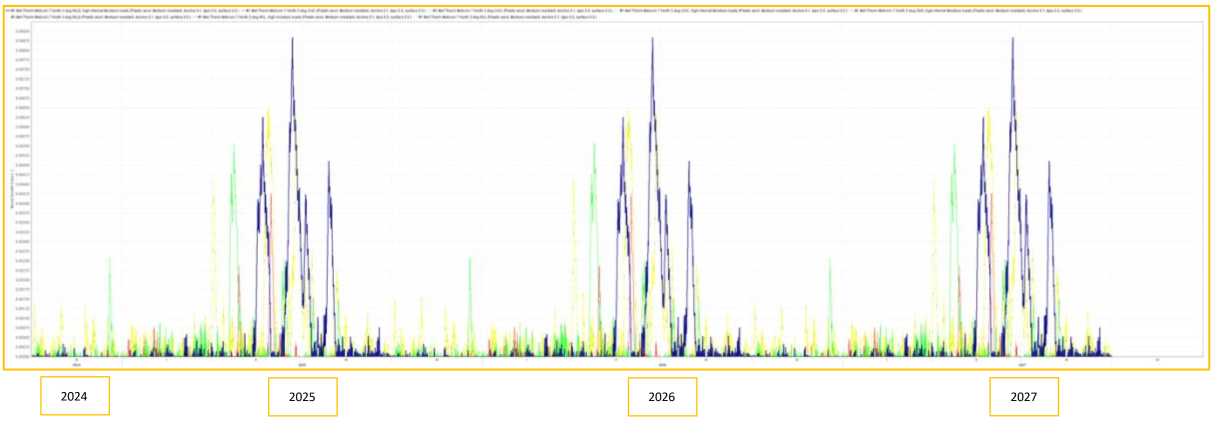


Typically our findings indicate that roof orientation becomes more significant as roof pitch increases, particularly in terms of solar gain and its influence on temperature and moisture management.

In this case we could not determine a significant difference between the orientations, even using darker surfaces. The moisture content in the exterior cavity was more affected by climatic location.

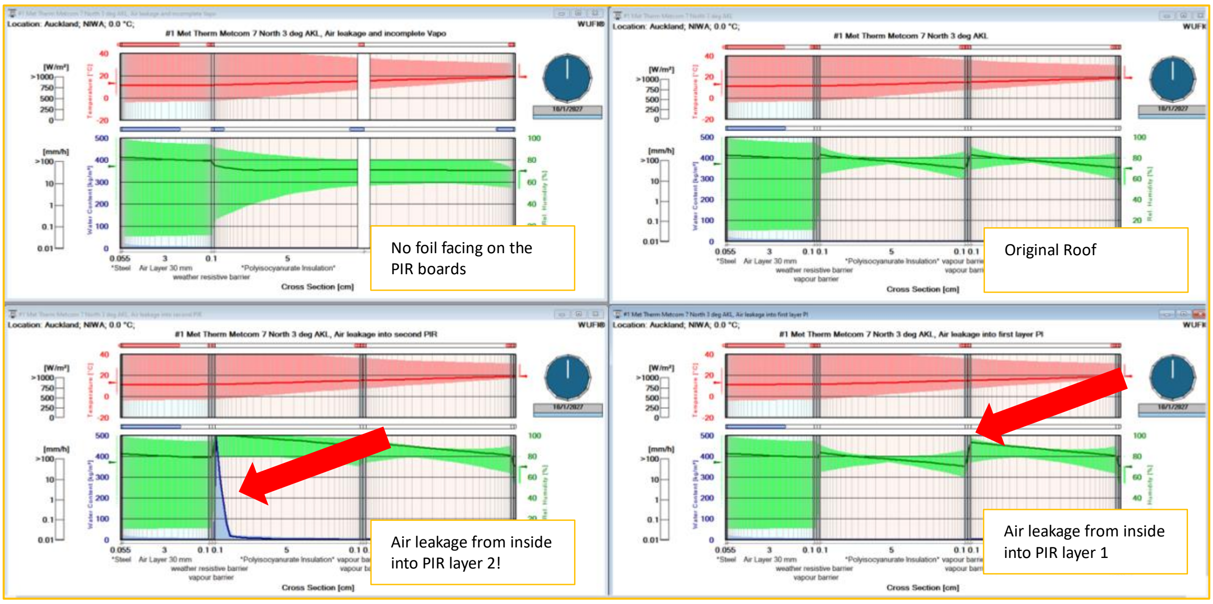
Internal Moisture Loads

Our analysis of internal moisture loads demonstrates that increases in indoor humidity levels do not adversely impact the roof system's performance. Even under conditions of heightened internal moisture from sources such as occupancy, cooking, and bathing, the roof assembly remains unaffected.
The materials and design of the Met-Therm system provide sufficient moisture control to prevent condensation or moisture buildup within the roof structure. This robustness ensures that even in buildings with higher internal humidity, the roof continues to perform effectively, maintaining its integrity and compliance with moisture-related regulations.



Additional Considerations

Incorrect or insufficient sealing of vapor barrier leading which could allow moisture ingress.



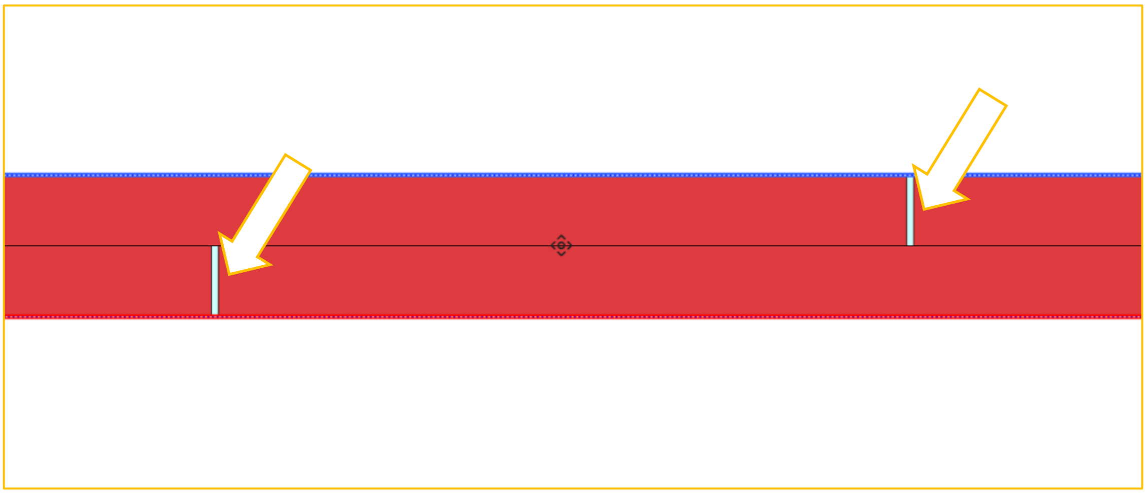
Our findings indicate that removing the foil face from the PIR insulation allows internal moisture to migrate through the PIR into the roof underlay. This scenario results in slightly elevated humidity levels in the roof underlay compared to previous calculations, though these levels remain non-critical. We conclude that the residual humidity can be effectively managed within the roof cavity through ventilation.

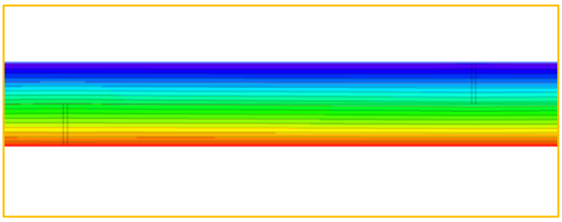
However, this does not imply that the vapor barrier at the steel tray level can be omitted. In fact, our analysis of a scenario where air infiltration is allowed into PIR layers 1 and 2 shows a problematic accumulation of moisture, which could lead to long-term issues.

The best practice, whether using foil-faced PIR or not, is to ensure that the vapor barrier at the steel liner is installed correctly and continuously to prevent any air or moisture ingress. This will ensure that the roof system maintains its performance and complies with moisture control requirements.

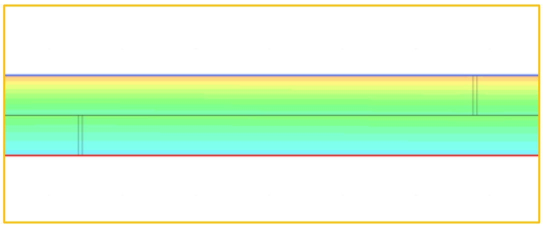
Installation gaps

We performed a 2D isothermal calculation using Flixo Pro (to DIN 4803) to evaluate the effects of small air gaps between insulation boards on temperature and humidity performance. The calculation modeled a 5mm air gap between the PIR boards, assessing its impact on the overall thermal and moisture behavior of the roof system.
Our findings show that this small air gap did not result in any significant changes in temperature or humidity performance. The difference was negligible, and no additional moisture accumulation or temperature fluctuations were observed. Therefore, minor air gaps of this size can be considered non-critical and are unlikely to compromise the system's moisture control or thermal integrity.





Temperature distribution



Humidity Distribution

compliance requirements

Clause E3, NZBC – internal moisture

Objective

E3.1 The objective of this provision is to:

- Safeguard people against illness, injury, or loss of amenity that could result from the accumulation of internal moisture; and
- Protect household units and other property from damage caused by free water from another household unit in the same building (applies to residential only).

Functional Requirement

E3.2 Buildings must be constructed to avoid the likelihood of:

- Fungal growth or the accumulation of contaminants on linings and other building elements.
- Free water overflow penetrating to an adjoining household unit; and
- Damage to building elements being caused by the presence of moisture.

Performance

E3.3.1 An adequate combination of

- thermal resistance, ventilation, and space temperature must be provided to all habitable spaces, bathrooms, laundries, and other spaces where moisture may be generated or may accumulate.

Verification Method

Alternative Solution, using ASHRAE160, DIN4108

compliance method

Managing moisture during transportation, storage, assembly, and installation

Transportation, storage, and assembly

When transporting, storing, or assembling wood, wood-based materials, or wooden components, it's essential to take suitable measures to prevent the moisture content from changing unfavorably due to factors like ground moisture, precipitation, adjacent structures, or drying out.

Installation moisture content

The relative humidity of the assembly components should not exceed 80% at 20ºC, unless otherwise stated.
It is recommended to use a protimeter to take samples at a min depth of 1/3 into the specimen.

Installation of other building and insulation materials

When installing other building and insulation materials within the cross-section of the component, ensure they do not lead to excessive moisture increase in adjacent materials.

Protection during construction phase

It is recommended that materials must be protected from precipitation during the construction phase. This protection does not apply to wood-based panels used as overlapping or folded non-load-bearing cladding, provided they are suitable for temporary exposure to weather conditions.

Prevention of excessive moisture increase

To prevent construction materials from experiencing excessive moisture due to high construction humidity (either direct moisture exposure or indirectly from high relative humidity), it is necessary to take steps. Rooms with high construction humidity and resulting high indoor humidity must be thoroughly ventilated, heated if necessary, or mechanically dried until the elevated construction moisture has dissipated. Ventilation air exchange is recommeded to achive $0.35h^{-1}$ to manage internal moisture loads under Clause G4 on average across the building. Where specific room- or use requirements apply it is recommended that a technical expert for HVAC be consulted.

Moisture in the operational state - external

Compliant detailing in accordance with Clause E2, External moisture is implied, unless otherwise stated. Continual moisture ingress into components from adjacent building and insulation materials must be prevented.

Moisture in the operational state - internal

In areas such as bathrooms and wet rooms in apartments without floor drains but with moderate use (e.g., areas with direct moisture exposure like shower splashes), the entry of excessive moisture into wooden components must be prevented. This requires ensuring that the respective surfaces, penetrations, and connections are waterproof according to generally accepted rules of technology, such as using a composite seal with regulatory usability verification in accordance with clause E3, AS1.

Condensation

Unfavorable changes in moisture content due to condensation from water vapor diffusion or convection must be prevented.
It must be ensured that no condensation forms on cold-water pipes within components. The components of the building envelope must be airtight against water vapor convection.

The condensation protection for the interior surface and cross-section of components should be proven according to ASHRAE160, DIN 4108-3 or DIN EN 15026 (equivalent to ASHRAE160).

For double-sided enclosed components of the building envelope, when using numerical simulation methods according to DIN EN 15026 (ASHRAE160), convective moisture ingress should is calculated based on the low air permeability, as a worst case scenario.

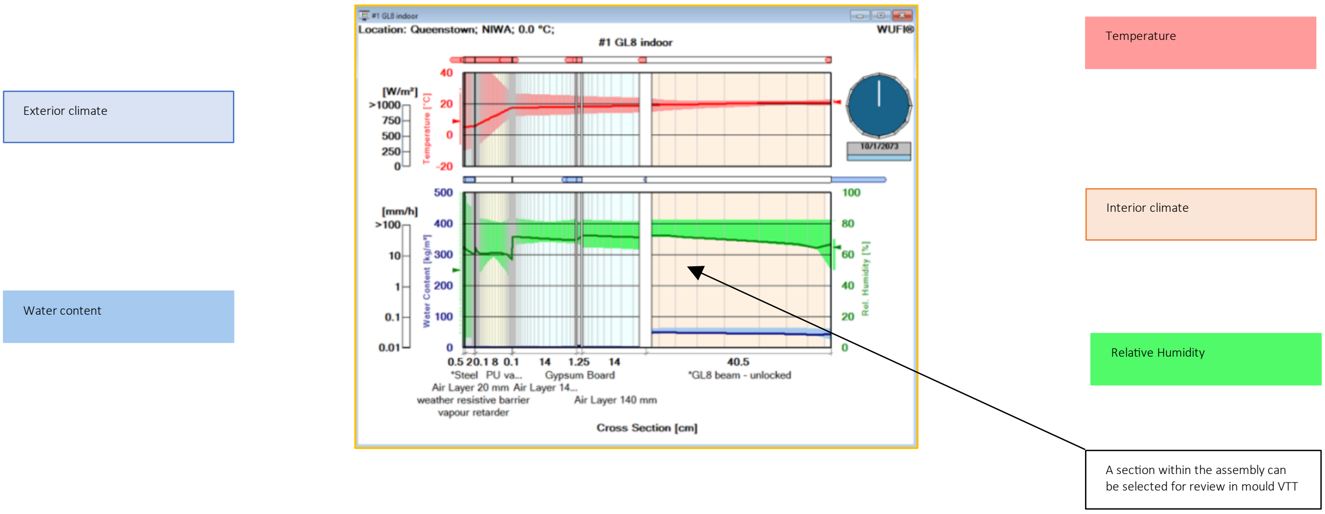
NOTE: Components of the building envelope include all components that border colder areas, such as external walls, roofs, walls, or ceilings adjacent to the ground, unheated basements, or attic spaces.

ASHRAE160 and method of biohygrothermal assessment – interpretation of results

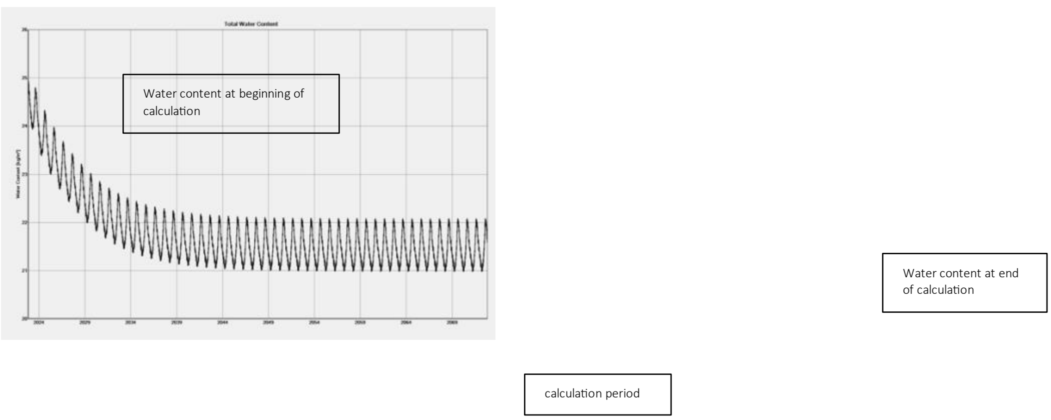
The biohygrothermal method used in WUFI and WUFI mould index VTT is a simulation technique employed to analyze the behavior of building assemblies, particularly with respect to moisture and heat transfer. The method involves creating computer models of building components like walls, roofs, and floors. These models consider the hygrothermal properties of materials, such as thermal conductivity, moisture storage, and vapor permeability. We use these models to simulate the movement of heat and moisture through building assemblies over time. This simulation accounts for climate conditions, indoor conditions, and the properties of building materials.

Using the post processing tool WUFI mould index VTT the basic WUFI model extends by considering biological activity, such as mold growth, in the simulation. It takes into account factors like temperature, humidity, and nutrient availability to predict the likelihood of mold growth and wood decay in building components.
This helps assess the risk of moisture-related problems in buildings, including mold growth, which can lead to health issues and damage to the structure. By simulating the moisture and heat behavior, they provide insights into potential problems and allow for adjustments in building design or materials to mitigate these risks.

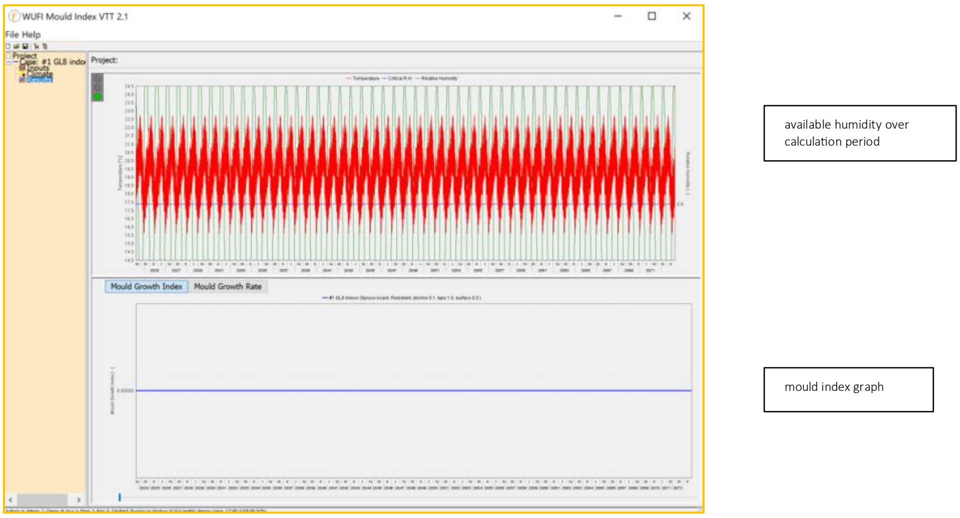
Typical section in WUFI



Water content of all, or selected components (simplified review)



Typical output in mould VTT



Mould Index Levels

The model is based on the **visual findings** of mould growth that is presented using mould index values. The mould index can have values from 0 to 6, representing the mould growth level on a surface detected by microscope or naked eye as described in the table below. Due to the sensory impression, the final evaluation of the mould growth level is left for the person who studies the level. For example, the laboratory observations for the different materials were typically carried out by the same person. Thus, the deviation caused by different personal interpretations of the findings could be kept low. The growth level within the same surface types can be evaluated relatively well, but some challenges occur when comparing the growth on smooth and porous surfaces.

The results are then evaluated in a traffic light system:

Mould Index	Description of the growth rate
0	No growth
1	Small amounts of mould on surface (microscope), initial stages of local growth
2	Several local mould growth colonies on surface (microscope)
3	Visual findings of mould on surface, < 10% coverage, or, < 50% coverage of mould (microscope)[1]
4	Visual findings of mould on surface, 10 – 50% coverage, or, > 50% coverage of mould (microscope)
5	Plenty of growth on surface, > 50% coverage (visual)
6	Heavy and tight growth, coverage about 100 %

statement

We believe, based on reasonable grounds and supported by sound and comprehensive assessment, that the roof system conforms to the compliance requirements of E3. However, the actual performance of the building is contingent upon the faithful execution of the underlying assumptions we have employed. Furthermore, achieving the anticipated performance necessitates diligent on-site commissioning and verification processes.

Denise Martin

Director, BEO Ltd

assumptions and limitations

WUFI input Roof

Construction Orientation	3º, 10º,20 ºand 40º, North East, South and West
Rain Coefficients/Construction Height (within building) to ASHRAE 160	To ASHRAE160
Surface Coefficients	SD;0m exterior SD;0m for interior
Calculation Period	3 years
Climate; external	Auckland, Wellington, Christchurch, Queenstown NIWA
Climate; internal	To ASHRAE 160, 18-25ºC, humidity profile high (0.000126, 1000m3), 0.1ACH
Initial Conditions	All materials 80% RH at 20ºC
Construction Assembly	
Materials	o Metal Roof, profile 0.55mm o 30mm ventilated cavity o Proclima Solitex Mento 3000 o 2 x 50mm, or 1 x 100mm foil faced PIR o Metal Roof, profile 0.55mm o Roof Purlins/Structure, open to the interior

Material Data

Material name	Density in kg/m3	Porosity in m3/m3	Specific heat capacity in J/kgK	Thermal conductivity λ, Dry, 10ºC in W/mK	WV Diffusion Resistance factor μ	Variable properties Yes/no/ material approximation
Steel	7800	0.01	450	50	1.000.000	Approximation
Weather Resistive Barrier	130	0.001	2300	2.3	500	
Vapour Barrier	130	0.001	2300	2.3	1,500,000	
Polyisocyanade insulation	26.5	.99	1470	0.023*	51.1	* average from different products (0.022 – 0.024)

Classification of vapour resistances to DIN4108-3;2018:

Term	S_d- value (range) (in m of equivalent air layer thickness)
Diffusion open/permeable	≤ 0.5 m
Diffusion inhibiting	0.5m ≤ S_d ≤ 10.0m
Diffusion retarding	10.0m ≤ S_d ≤ 100.0m
Diffusion blocking	100m ≤ S_d ≤ 1,500m
Diffusion impermeable	≥ 1,500m

Reference documents

NZS 2295:2006	Pliable Permeable Building Underlays
NZBC Clause E3	Internal Moisture
AS/NZS ISO 9972: 2015	Thermal Performance of Buildings - Determination of Air Permeability of Buildings - Fan Pressurization Method
DIN 4108-3;2018-3	Thermal protection and energy economy in Buildings: Part 3; Protection against moisture subject to climate conditions, requirements, Calculation methods and directions for planning and construction
DIN 68800-1	Wood Preservation – Part 1, General
DIN 68800-2	Wood Preservation – Part 2, Preventive Constructional Measures in buildings
DIN EN 15026:2007-07	Hygrothermal performance of building components and building elements - Assessment of moisture transfer by numerical simulation; German version EN 15026:2007
DIN EN ISO 13788 ; 2012	Hygrothermal performance of building components and building elements - Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods (ISO 13788:2012); German version EN ISO 13788:2012
ANSI/ASHRAE Standard 160-2016	ANSI/ASHRAE Standard 160-2016, Criteria for Moisture-Control Design Analysis in Buildings

appendices


#1 Met Therm Metcom 7 North 3 deg WLG, high internal Moisture loads (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg CHC (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg CHC (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg CHC, high internal Moisture loads (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg ZQN, high internal Moisture loads (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg WLG (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg AKL, high moisture loads (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg AKL (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
Mould Growth Index [-]
0.00850
0.00825
0.00800
0.00775
0.00750
0.00725
0.00700
0.00675
0.00650
0.00625
0.00600
0.00575
0.00550
0.00525
0.00500
0.00475
0.00450
0.00425
0.00400
0.00375
0.00350
0.00325
0.00300
0.00275
0.00250
0.00225
0.00200
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
IV
2024
I
II
2025
III
IV
I
II
2026
III
IV
I
II
2027
III
IV

#1 Met Therm Metcom 7 North 3 deg AKL (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg AKL (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#2 Met Therm Metcom 7 North 3 deg WLG (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#3 Met Therm Metcom 7 North 3 deg CHC (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#4 Met Therm Metcom 7 North 3 deg ZQN (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#4 Met Therm Metcom 7 North 3 deg ZQN (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
#3 Met Therm Metcom 7 North 3 deg CHC (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
#2 Met Therm Metcom 7 North 3 deg WLG (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
Mould Growth Index [-]
IV
2024
I
II
2025
III
IV
I
II
2026
III
IV
I
II
2027
III


#2 Met Therm Metcom 7 South 40 deg WLG (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#4 Met Therm Metcom 7 South 40 deg ZQN (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#3 Met Therm Metcom 7 South 40 deg CHC (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#2 Met Therm Metcom 7 South 40 deg WLG (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 South 40 deg AKL (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#4 Met Therm Metcom 7 South 40 deg ZQN (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#3 Met Therm Metcom 7 South 40 deg CHC (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 South 40 deg AKL (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
Mould Growth Index [-]
0.038
0.037
0.036
0.035
0.034
0.033
0.032
0.031
0.030
0.029
0.028
0.027
0.026
0.025
0.024
0.023
0.022
0.021
0.020
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
IV
I
II
III
IV
I
II
III
IV
I
II
III
IV
2024
2025
2026
2027


#1 Met Therm Metcom 7 North 3 deg Christchurch 10 ACH dark (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg Christchurch 10 ACH (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
Mould Growth Index [-]
0.00600
0.00575
0.00550
0.00525
0.00500
0.00475
0.00450
0.00425
0.00400
0.00375
0.00350
0.00325
0.00300
0.00275
0.00250
0.00225
0.00200
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
IV
2024
I
II
2025
III
IV
I
II
2026
III
IV
I
II
2027
III
IV


#1 Met Therm Metcom 7 North 3 deg AKL, Air leakage into first layer PI (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg AKL, Air leakage and incomplete Vapo (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg AKL, Air leakage into second PIR (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg AKL (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
Mould Growth Index [-]
2024
2025
2026
2027

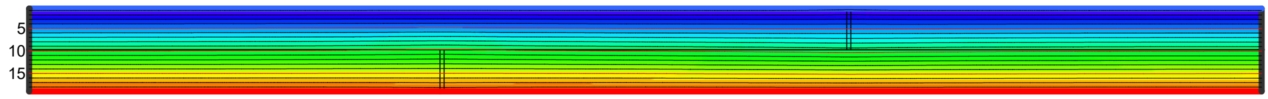
#1 Met Therm Metcom 7 North 3 deg AKL (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#2 Met Therm Metcom 7 North 3 deg AKL dark single layer PIR (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
#2 Met Therm Metcom 7 North 3 deg AKL bright single layer PIR (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
#2 Met Therm Metcom 7 North 3 deg AKL dark (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 3 deg AKL (PU-insulation with Al-foil: Sensitive, decline 0.25, type 0.0, surface 0.0)
#2 Met Therm Metcom 7 North 3 deg AKL dark (Polyester wool: Medium resistant, decline 0.1, type 1.0, surface 0.0)
Mould Growth Index [-]
2024
2025
2026
2027

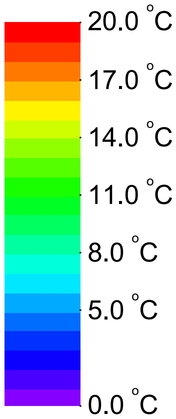

#1 Met Therm Metcom 7 West 40 deg AKL (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 East 40 deg AKL (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 North 40 deg AKL (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#1 Met Therm Metcom 7 South 40 deg AKL (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
Mould Growth Index [-]
0.0041
0.0040
0.0039
0.0038
0.0037
0.0036
0.0035
0.0034
0.0033
0.0032
0.0031
0.0030
0.0029
0.0028
0.0027
0.0026
0.0025
0.0024
0.0023
0.0022
0.0021
0.0020
0.0019
0.0018
0.0017
0.0016
0.0015
0.0014
0.0013
0.0012
0.0011
0.0010
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
IV
2024
I
II
2025
III
IV
I
II
2026
III
IV
I
II
2027
III


#4 Met Therm Metcom 7 West 40 deg ZQN (PU-insulation with Al-foil: Medium resistant, decline 0.25, type 0.0, surface 0.0)
#4 Met Therm Metcom 7 South 40 deg ZQN (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#4 Met Therm Metcom 7 East 40 deg ZQN (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
#4 Met Therm Metcom 7 North 40 deg ZQN (Plastic wool: Medium resistant, decline 0.1, type 0.0, surface 0.0)
Mould Growth Index [-]
0.0030
0.0029
0.0028
0.0027
0.0026
0.0025
0.0024
0.0023
0.0022
0.0021
0.0020
0.0019
0.0018
0.0017
0.0016
0.0015
0.0014
0.0013
0.0012
0.0011
0.0010
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
IV
I
II
III
IV
I
II
III
IV
I
II
III
IV
2024
2025
2026
2027

BEO Buildingscience

Staggered PIR Panels Temperature





Material	λ[W/(m·K)]
Aluminium alloy	160.000
Phenolharz-Hartschaum Nennwert L=0.025	0.025
Steel	50.000
Unventilated air cavity *	
* Simplified approach	

Boundary Condition	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior, roof cavity		0.000	0.130	
Interior fRSi		20.000	0.250	
Symmetry/Model section	0.000			

Staggered PIR panels Humidity