

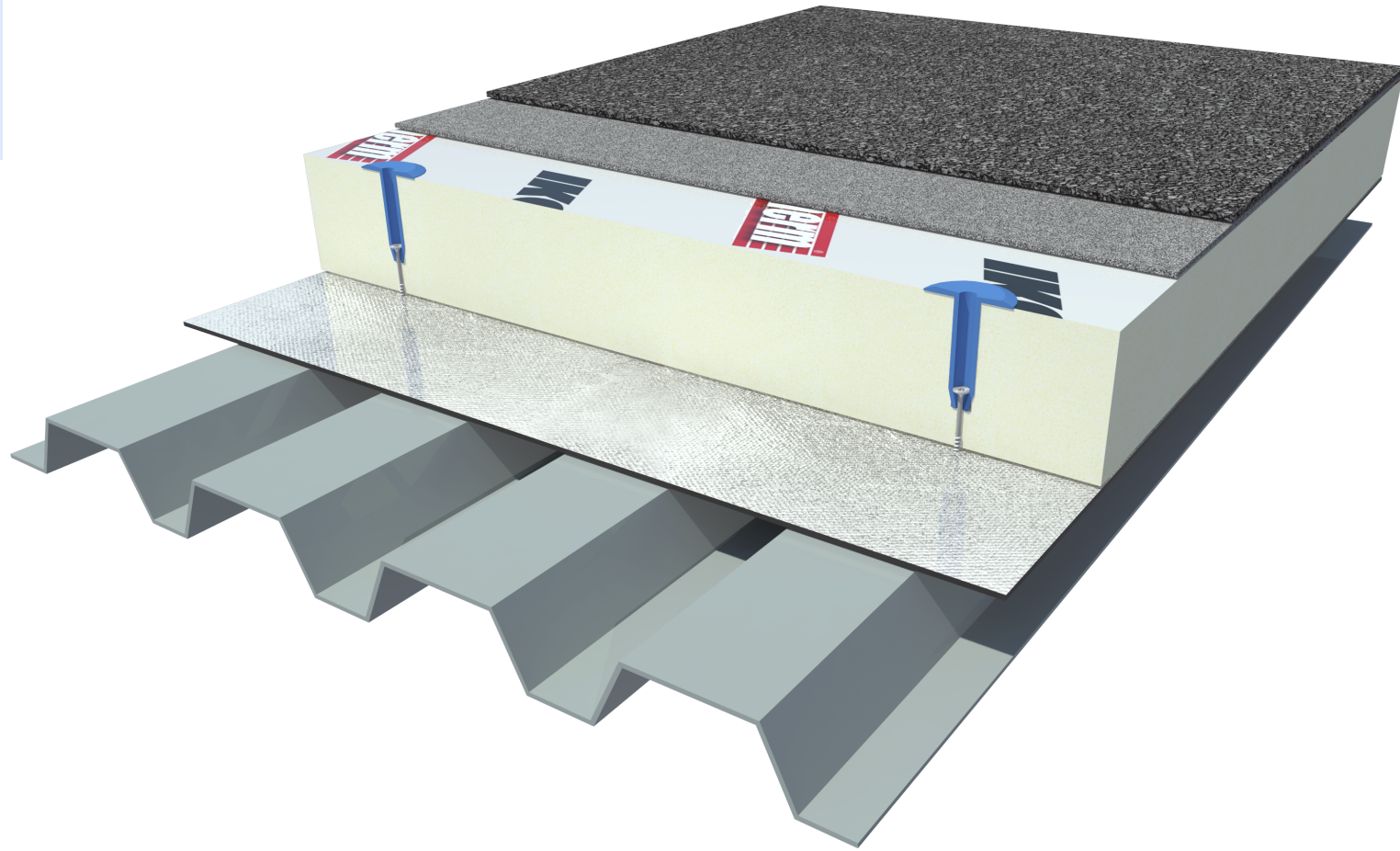
A photograph of a modern, multi-story building with a warm roof and large glass windows, illuminated at dusk. The building features a mix of brick and glass facades, with balconies and a prominent glass-enclosed stairwell. The text "Design Considerations for Warm Roofs" is overlaid in white. The background shows a clear blue sky and some street lighting.

Design Considerations for Warm Roofs

Three design considerations when specifying a Warm Roof:

- 1. When is a warm roof not a warm roof?**
- 2. What affect does mechanical fixing through a continuous insulation layer have?**
- 3. How do we add extra layers of protection when designing a warm roof?**

Peter Mills Nuralite



Inside:

Reduced air circulation

20

 °C

50

 % Humidity

Rsi...

From inside to outside:

reverse

		Thickness	Width	Distance	λ	μ			
:: 1	trapezoidal sheet	30 mm			10	sd=10			 
:: 2	Generic PIR	40 mm			0,024	60/100000			 
:: 3	Polyvinylchlorid (PVC)	1,5 mm			0,17	50000			 
:: 4		mm							

Outside:

Direct contact to outside air

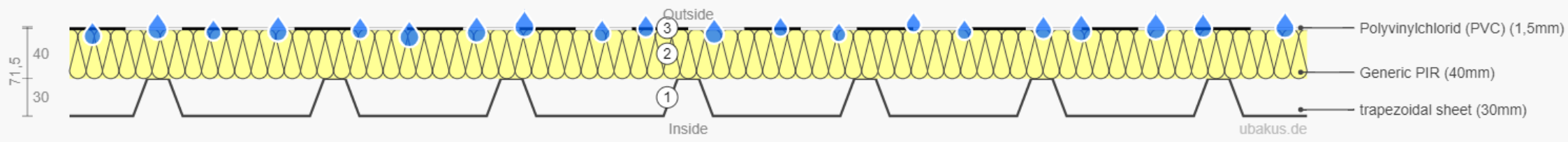
0

 °C

80

 % Humidity

Rse...



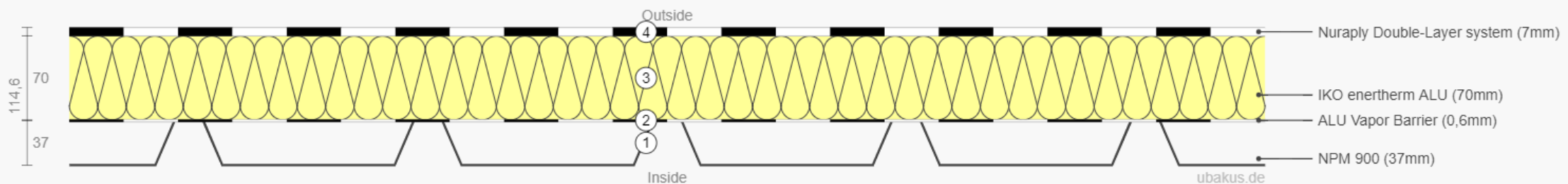
- Input
- Input
- U-value
- LCA
- Moisture
- Heat
- Diagrams
- Hints

Inside: Reduced air circulation 20 °C 50 % Humidity Rsi...

From inside to outside: reverse

		Thickness	Width	Distance	λ	μ			
:: 1	NPM 900	37	mm		10	sd=10			
:: 2	ALU Vapor Barrier	0,6	mm		1000	sd=1500			
:: 3	IKO enertherm ALU	70	mm		0,022	60/100000			
:: 4	Nuraply Double-Layer system	7	mm		0,23	50000			
:: 5			mm						

Outside: Direct contact to outside air 0 °C 80 % Humidity Rse...



R-value: 3,22 m²K/W

GEG 2020 Bestand: U ≤ 0.24*

Contribution to the greenhouse effect:

excellentinsufficient

Condensate: 0 kg/m²

moisture content of wood: +0,0 %

Drying time: -

excellentinsufficient

sd-value: 1864 m

Interior surface: 18,6°C (55%)

Drying reserve: 2 g/m²a

insufficientexcellent

Thickness: 11,46 cm

Weight: 14 kg/m²

temp. amplitude damping (1/TAV): 1,6

phase shift: 3,9 h

Heat storage capacity: 5.8 kJ/m²K

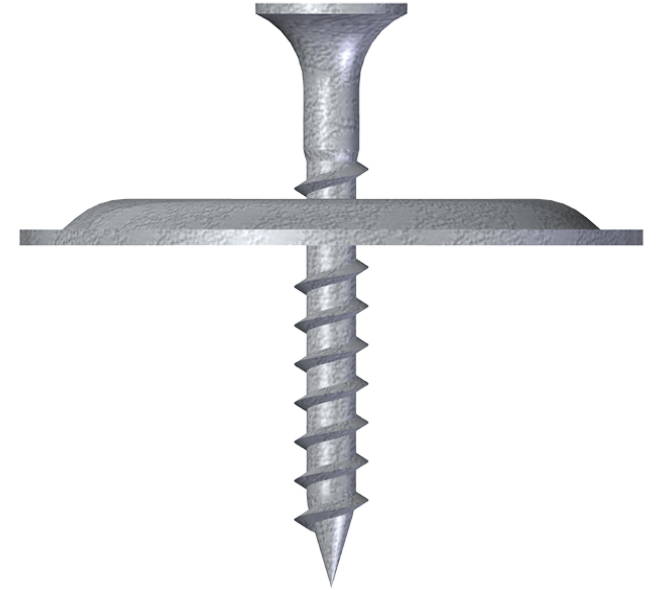
insufficientexcellent

Denise Martin Oculus

Thermal bridging
through the
insulation layer



Thermally Broken
Fixing



Standard Screw
Fixing

Approximation for U-Value Supplement for mechanical fasteners



$\alpha = 0,8 \times \frac{d_1}{d_0}$ For penetration of fasteners through a thermal break fixing tube (fig F.1)

- 1 thermal break fixing tube
- 2 fastener
- 3 insulation
- 4 substrate

$$\Delta U_f = \alpha \cdot \frac{\lambda_f \cdot A_f \cdot n_f}{d_0} \cdot \left(\frac{R_1}{R_{\text{tot}}} \right)^2$$

 λ_f Thermal conductivity of fastener in W/mK

n_f number of fasteners per m²

A_f fastener cross section in m^2

d_0 Depth of insulation in m

d_1 Depth of fastener through insulation in m

 R_1 R-Value of insulation layer in $\text{m}^2\text{K/W}$

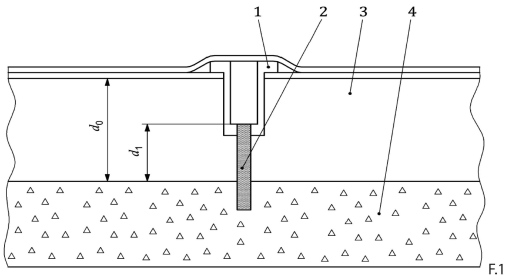
R_{tot} Total System R-Value in $\text{m}^2\text{K/W}$



Assembly no.	Building assembly description				Interior insulation?	
01ud						
	Heat transmission resistance [m ² K/W]					
Orientation of building element	interior R _{si}		exterior R _{se}			
Adjacent to						
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Diameter of sec. 1	Percentage of sec. 2		Percentage of sec. 3		Total	cm
100%						
U-value supplement	W/(m ² K)		U-value:		W/(m ² K)	



Installation example



- $\alpha = 0,8$ For full depth penetration of fasteners through the insulation
 $\alpha = 0,8 \times \frac{d_1}{d_0}$ For penetration of fasteners through a thermal break fixing tube (fig F.1)
- 1 thermal break fixing tube
 - 2 fastener
 - 3 insulation
 - 4 substrate

$$\Delta U_f = \alpha \cdot \frac{\lambda_f \cdot A_f \cdot n_f}{d_1} \cdot \left(\frac{R_1}{R_{tot}} \right)^2$$

λ_f 50 W/mK

n_f 6

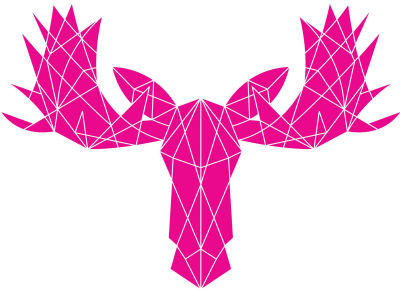
A_f screw diameter 6mm ($\Rightarrow \text{Pi} \cdot r^2 \approx 0.000113\text{m}^2$)

d_0 0.1 m

d_1 0.02 m

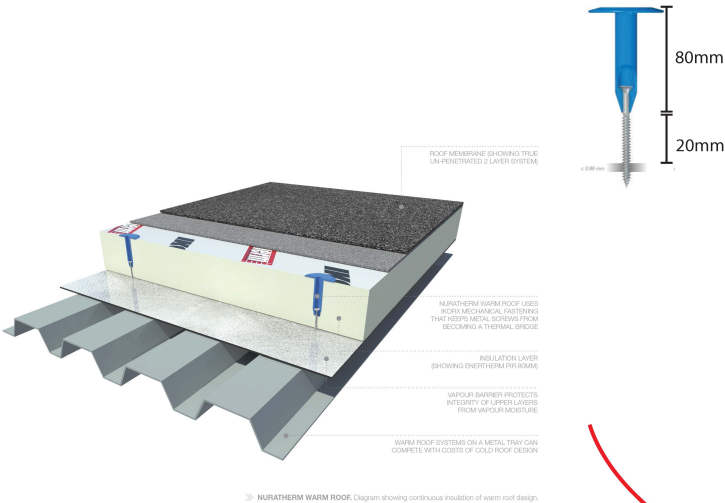
R_1 ($= 0.1\text{m}/0.026 \text{ (m K)}/\text{W}$) $= > 3.85\text{W}/\text{m}^2\text{K}$

R_{tot} 4.115 $\text{m}^2\text{K}/\text{W}$



oculus

Nuralite Roof Example

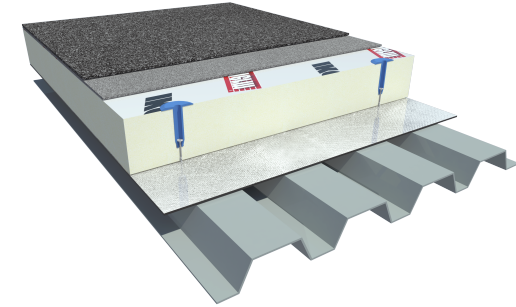


Assembly no.	Building assembly description		Interior insulation?			
01ud	Nuralite Roof					
Orientation of building element		Heat transmission resistance [m²K/W]				
Adjacent to		interior R _{si}	0.17			
		exterior R _{se}	0.04			
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Roof membrane; 2 layer Torch on	0.170					10
Enetherm IKO PIR (32kg/m³)	0.026					100
Vapour Barrier						
Metal Tray (steel)	50.000					4
Percentage of sec. 1		Percentage of sec. 2		Percentage of sec. 3		Total
100%						11.4 cm
U-value supplement				U-value: 0.243 W/(m²K)		
				R-Value: 4.115 (m²K)/W		

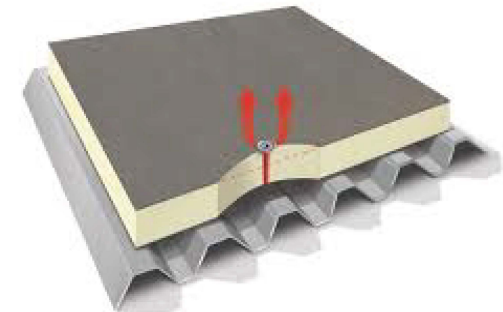
Constructed R-values

6 Fastners per sqm

Assembly no.	Building assembly description		Interior insulation?		
01ud	Nuralite Roof				
Heat transmission resistance [m²K/W]					
Orientation of building element	0.1	interior R _{si}	0.10		
Adjacent to	0.04	exterior R _{se}	0.04		
Area section 1 λ [W/(mK)] Area section 2 (optional) λ [W/(mK)] Area section 3 (optional) λ [W/(mK)] Thickness [mm]					
Roof membrane; 2 layer Torch on	0.170				10
Enetherm IKO PIR (32kg/m³)	0.026				100
Vapour Barrier					
Metal Tray (steel)	50.000				4
Percentage of sec. 1 Percentage of sec. 2 Percentage of sec. 3 Total					
100% 11.4 cm					
U-value supplement 0.06 W/(m²K)					
U-value: 0.309 W/(m²K)					
R-Value: 3.233 (m²K)/W					



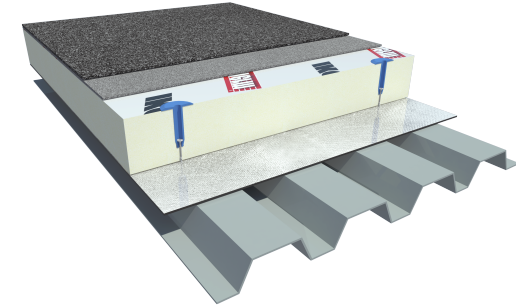
Assembly no.	Building assembly description		Interior insulation?		
01ud	Nuralite Roof				
Heat transmission resistance [m²K/W]					
Orientation of building element	0.1	interior R _{si}	0.10		
Adjacent to	0.04	exterior R _{se}	0.04		
Area section 1 λ [W/(mK)] Area section 2 (optional) λ [W/(mK)] Area section 3 (optional) λ [W/(mK)] Thickness [mm]					
Roof membrane; 2 layer Torch on	0.170				10
Enetherm IKO PIR (32kg/m³)	0.026				100
Vapour Barrier					
Metal Tray (steel)	50.000				4
Percentage of sec. 1 Percentage of sec. 2 Percentage of sec. 3 Total					
100% 11.4 cm					
U-value supplement 0.31 W/(m²K)					
U-value: 0.557 W/(m²K)					
R-Value: 1.795 (m²K)/W					



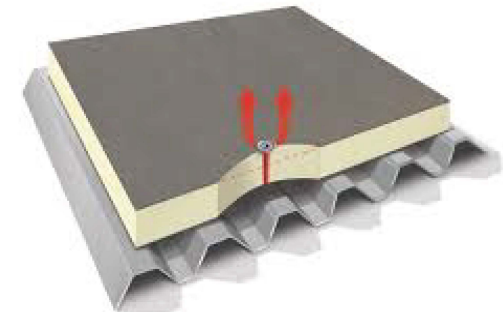
Constructed R-values

9 Fastners per sqm

Assembly no.	Building assembly description				Interior insulation?	
01ud	Nuralite Roof					
Orientation of building element		Heat transmission resistance [m²K/W]				
Adjacent to		interior R _{si}		0.10		
0.1		exterior R _{se}		0.04		
0.04						
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Roof membrane; 2 layer Torch on	0.170					10
Enetherm IKO PIR (32kg/m³)	0.026					100
Vapour Barrier						
Metal Tray (steel)	50.000					4
Percentage of sec. 1	100%	Percentage of sec. 2		Percentage of sec. 3		Total
						11.4 cm
U-value supplement	0.09 W/(m²K)	U-value: 0.340 W/(m²K)				
		R-Value: 2.938 (m²K)/W				



Assembly no.	Building assembly description				Interior insulation?	
01ud	Nuralite Roof					
Orientation of building element		Heat transmission resistance [m²K/W]				
Adjacent to		interior R _{si}		0.10		
0.1		exterior R _{se}		0.04		
0.04						
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Roof membrane; 2 layer Torch on	0.170					10
Enetherm IKO PIR (32kg/m³)	0.026					100
Vapour Barrier						
Metal Tray (steel)	50.000					4
Percentage of sec. 1	100%	Percentage of sec. 2		Percentage of sec. 3		Total
						11.4 cm
U-value supplement	0.47 W/(m²K)	U-value: 0.713 W/(m²K)				
		R-Value: 1.402 (m²K)/W				



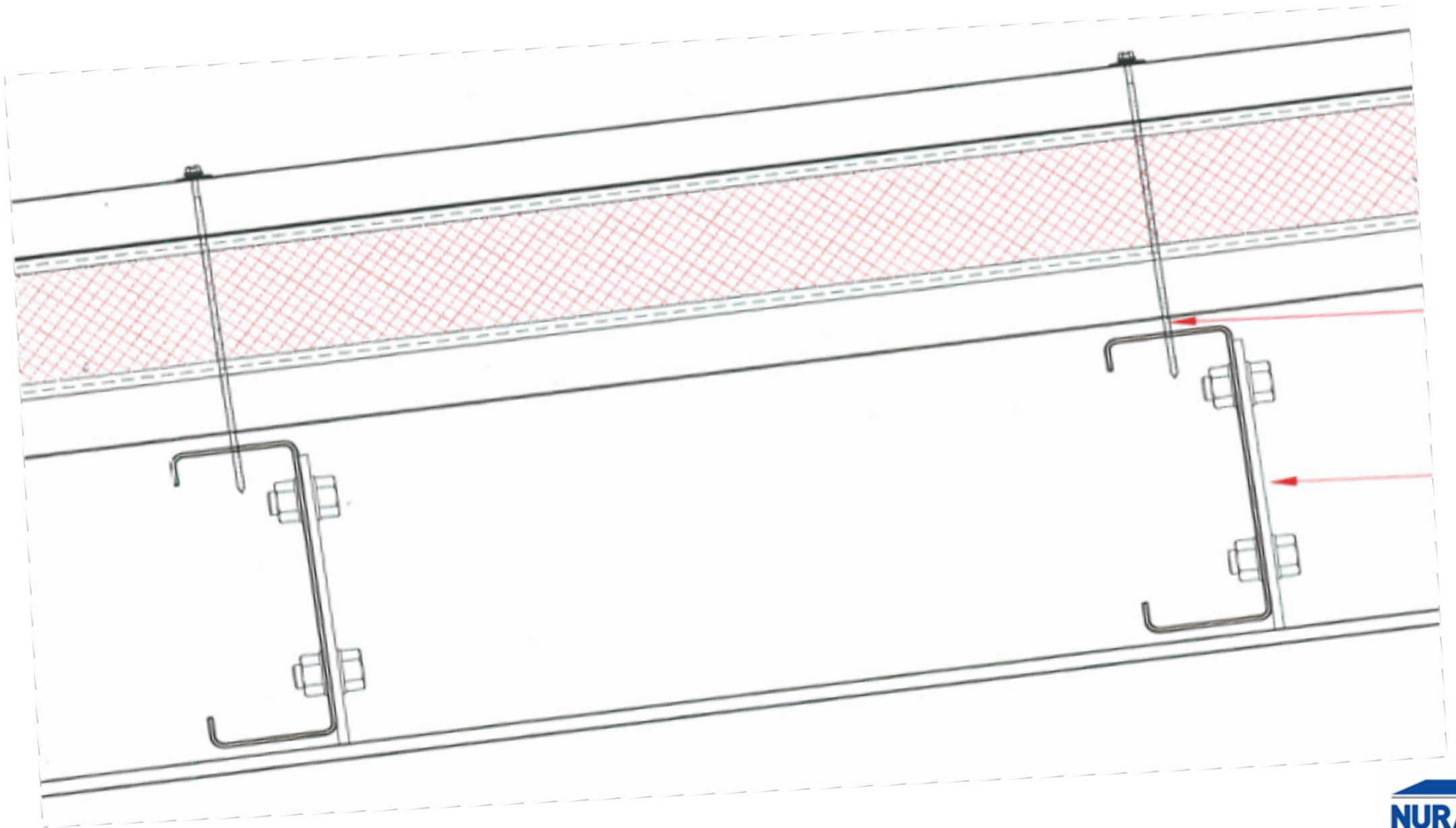
	6 Fastners per sqm	9 Fastners per sqm
Thermally Broken Fixing	U-Value: 0.309 R-Value: 3.233	U-Value: 0.340 R-Value: 2.938
Standard Screw Fixing (Conductive)	U-Value: 0.557 R-Value: 1.795	U-Value: 0.713 R-Value: 1.402

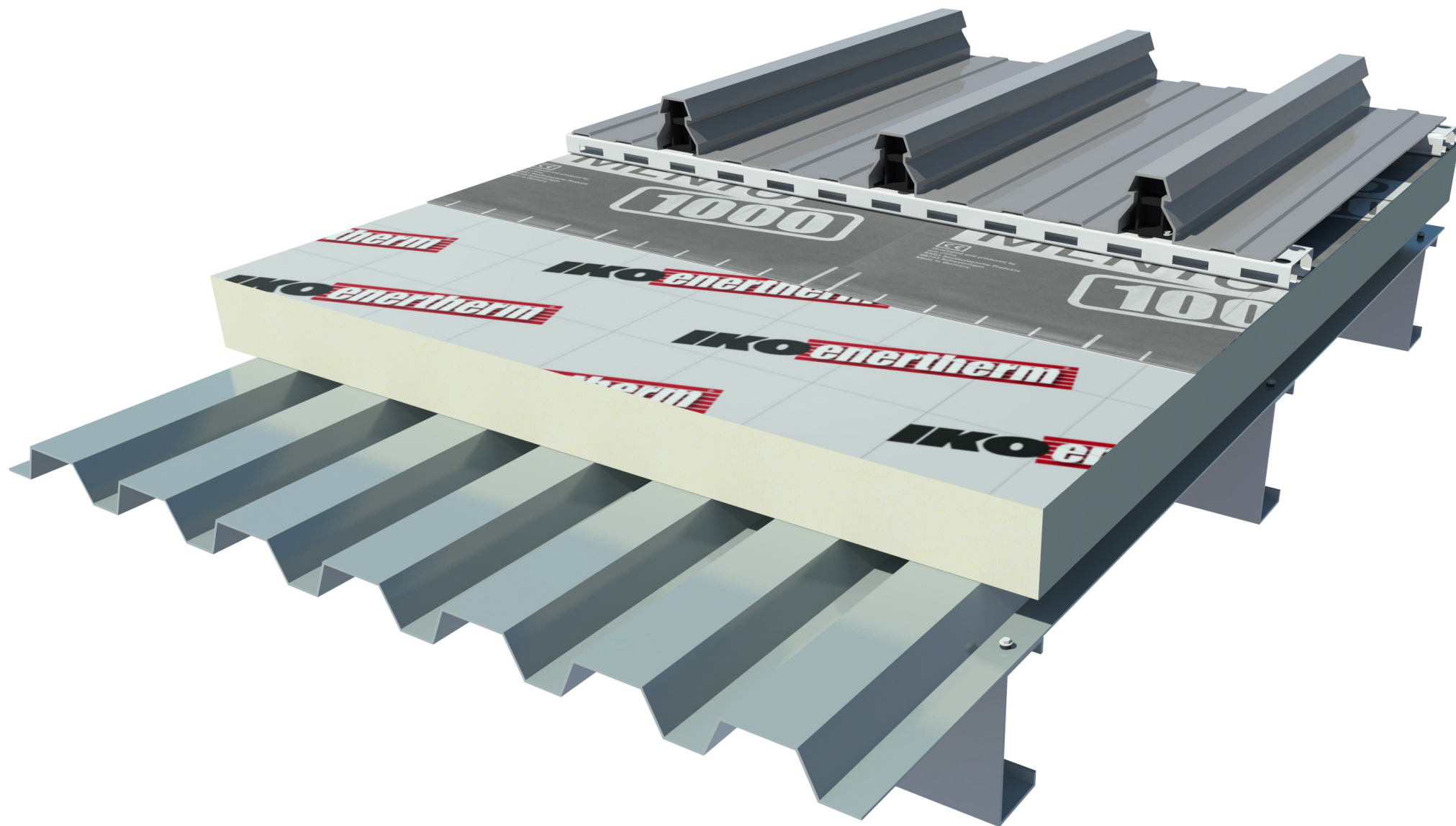
Vented Base Sheet











Three design considerations when specifying a Warm Roof:

1. When is a warm roof not a warm roof?

Insulation layer must be thick enough to eliminate condensation.

2. What affect does mechanical fixing through a continuous insulation layer have?

Can affect the overall performance of the insulation by up to 50%.

3. How do we add extra layers of protection when designing a warm roof?

Additional vapour diffusion layer.