VALIDATION OF THE CONDENSATION FEATURE (TRISCO) ACCORDING TO EN ISO 13788

Introduction

EN13788_RESULTS.xlsx

Annex C of the standard EN ISO 13788[1] contains 6 examples of an interstitial condensation calculation and 1 example on drying of a wetted layer.
The following validation examples will be simulated with the CONDENSATION feature in the program TRISCO.

- C2 Example 1: Building component with condensation in one interface plane
- C3 Example 2: Building component with condensation in two interfaces*
- C4 Example 3: Building component containing a well ventilated cavity
- C5 Example 4: Building component in a warm humid climate
- C6 Example 5: Division of a layer with high thermal resistance
- D Example of the calculation of the drying of a wetted layer

* This validation example is excluded here as the data mentioned in EN ISO 13788 contains errors

Boundary conditions

Several of the validation examples make use of the boundary condition given in Annex C.1. Figure 1 shows the monthly mean external (side 1) and internal (side 2) temperature and relative humidity.

Month	External		Internal Normal occupancy		Internal High occupancy	
	θ_e °C	φ_e %	θ_e °C	φ_e %	θ_e °C	φ_e %
January	-1	85	20.0	39	20.0	49
February	0	84	20.0	40	20.0	50
March	4	78	20.0	44	20.0	54
April	9	72	20.0	49	20.0	59
May	14	68	22.0	54	22.0	64
June	18	69	24.0	58	24.0	68
July	19	73	24.5	59	24.5	69
August	19	75	24.5	59	24.5	69
September	15	79	22.5	55	22.5	65
October	10	83	20.0	50	20.0	60
November	5	88	20.0	45	20.0	55
December	1	88	20.0	41	20.0	51

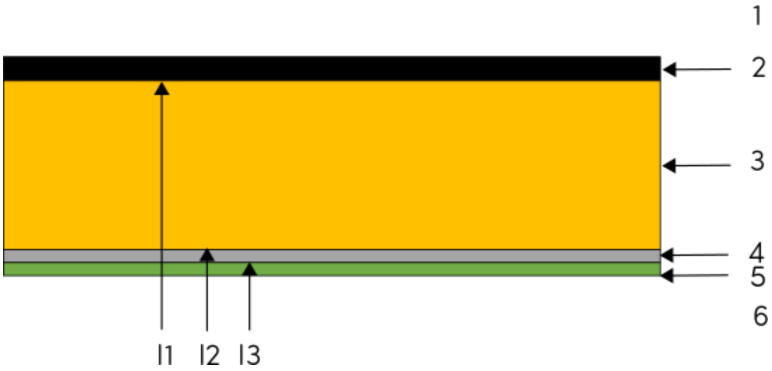
Figure 1. Boundary conditions

[1] 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

C.2-Example 1: Condensation at 1 interface

C2_NORMAL.trc
C2_HIGH.trc

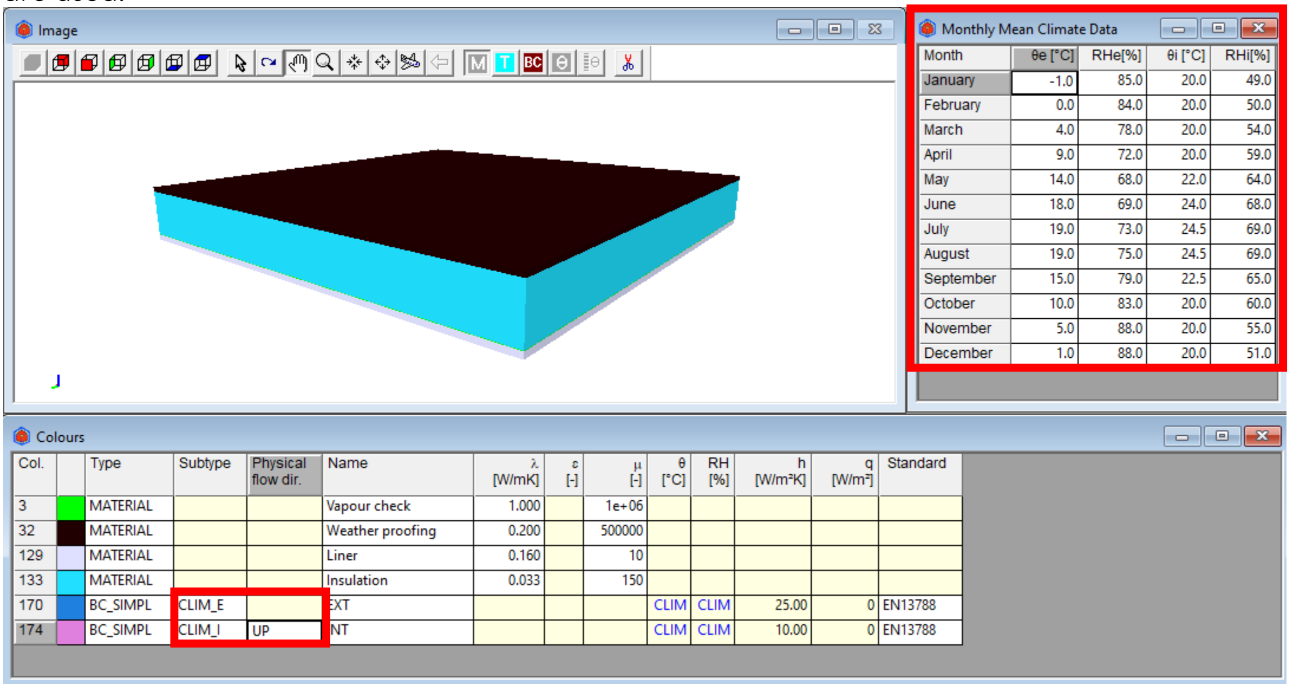
In this example, a flat roof with an impermeable weather proofing layer over the insulation is analysed. Figure 2 shows the roof built-up. The roof is analysed for both the normal and high occupy levels.



Key
1 external air
2 weatherproofing
3 insulation
4 vapour check
5 liner
6 inside air

Figure 2. Layers and interfaces in roof

The geometry modelled in TRISCO with blocks. Also for the small layer (e.g. vapour check) blocks are used.



Monthly Mean Climate Data

Month	θe [°C]	RHe[%]	θi [°C]	RHi[%]
January	-1.0	85.0	20.0	49.0
February	0.0	84.0	20.0	50.0
March	4.0	78.0	20.0	54.0
April	9.0	72.0	20.0	59.0
May	14.0	68.0	22.0	64.0
June	18.0	69.0	24.0	68.0
July	19.0	73.0	24.5	69.0
August	19.0	75.0	24.5	69.0
September	15.0	79.0	22.5	65.0
October	10.0	83.0	20.0	60.0
November	5.0	88.0	20.0	55.0
December	1.0	88.0	20.0	51.0

Colours

Col.		Type	Subtype	Physical flow dir.	Name	λ [W/mK]	ε [-]	μ [-]	θ [°C]	RH [%]	h [W/m²K]	q [W/m²]	Standard
3		MATERIAL			Vapour check	1.000		1e+06					
32		MATERIAL			Weather proofing	0.200		500000					
129		MATERIAL			Liner	0.160		10					
133		MATERIAL			Insulation	0.033		150					
170		BC_SIMPL	CLIM_E		EXT				CLIM	CLIM	25.00	0	EN13788
174		BC_SIMPL	CLIM_I	UP	NT				CLIM	CLIM	10.00	0	EN13788

Figure 3. Material properties in TRISCO

To be in line with EN ISO 13788 select a vapour permeability of air equal to 2 10-10 kg/(m.s.Pa) and condensation only on surface (Calculation parameters):

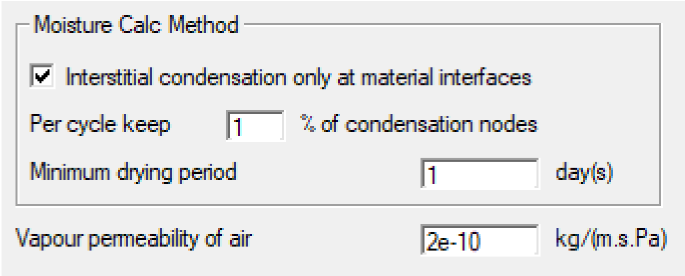
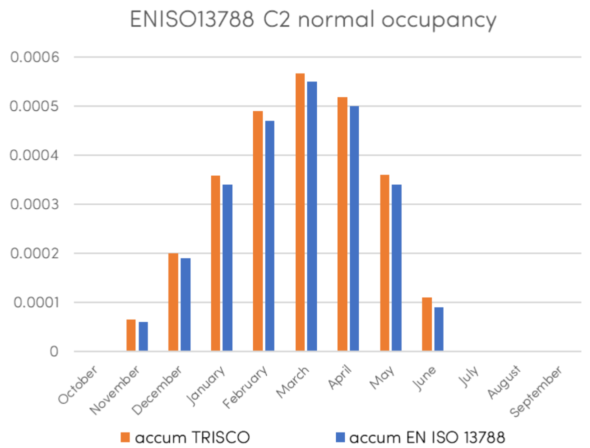
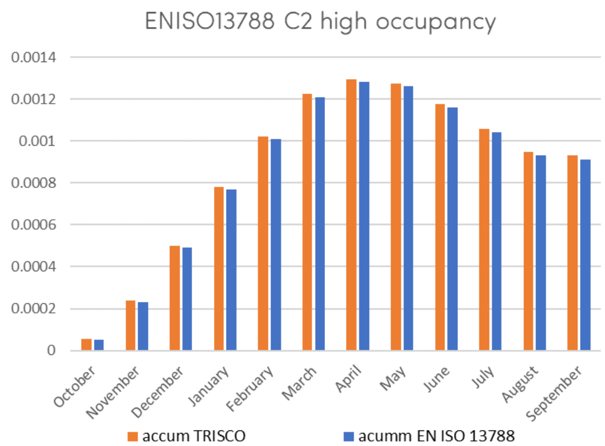


Figure 4. Moisture Calculation parameters



Normal occupancy

Month	TRISCO results		table C.3 EN 13788	
	condensation rate g_c [kg/m^2]	accumulation rate M_a [kg/m^2]	condensation rate g_c [kg/m^2]	accumulation rate M_a [kg/m^2]
October	0	0	0	0
November	0.000065	0.000065	0.00006	0.00006
December	0.000135	0.0002	0.00013	0.00019
January	0.000158	0.000358	0.00015	0.00034
February	0.000131	0.000489	0.00013	0.00047
March	0.000078	0.000567	0.00008	0.00055
April	-0.000049	0.000518	-0.00005	0.00050
May	-0.00016	0.000359	-0.00016	0.00034
June	-0.00025	0.000109	-0.00025	0.00009
July	-0.000109	0	-0.00028	0.00000
August	0	0	0	0.00000
September	0	0	0	0.00000



High occupancy

Month	TRISCO results		table C.3 EN 13788	
	condensation rate g_c [kg/m^2]	accumulation rate M_a [kg/m^2]	condensation rate g_c [kg/m^2]	accumulation rate M_a [kg/m^2]
October	0.000055	0.000055	0.00005	0.00005
November	0.000185	0.00024	0.00018	0.00023
December	0.000258	0.000498	0.00026	0.00049
January	0.000281	0.000779	0.00028	0.00077
February	0.000242	0.001022	0.00024	0.00101
March	0.000202	0.001223	0.0002	0.00121
April	0.00007	0.001293	0.00007	0.00128
May	-0.00002	0.001273	-0.00002	0.00126
June	-0.000097	0.001176	-0.0001	0.00116
July	-0.000117	0.001059	-0.00012	0.00104
August	-0.000112	0.000947	-0.00011	0.00093
September	0	0	-0.00002	0.00091

Figure 5. TRISCO results for example C.2 compared with the standard

Figure 5 shows the condensation rate and the condensation accumulation rate obtained by TRISCO and listed in the standard, both for a situation with a normal and a high occupancy. The rates are practically identical.

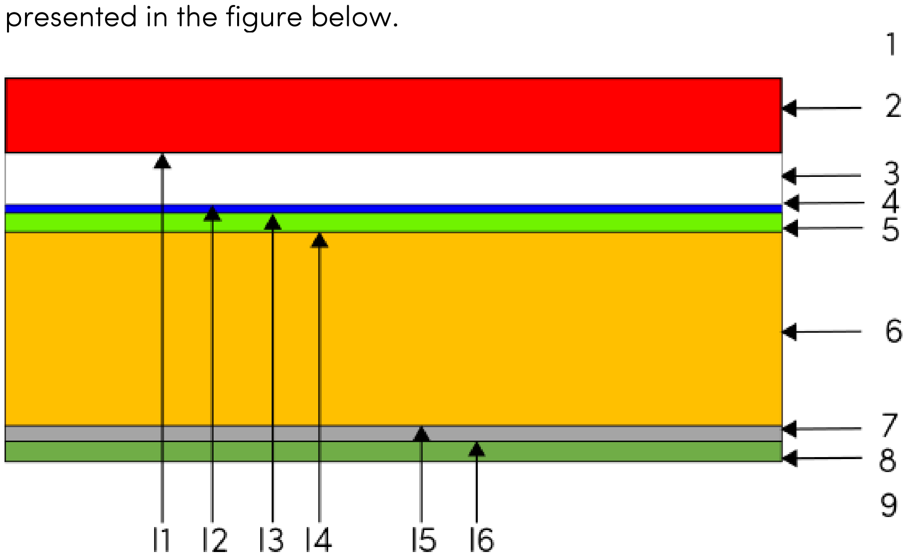
C.4-Example 3: Building component containing a well-ventilated cavity

In this validation example no condensation or drying is found. Consequently, this validation case is not relevant for validation purposes and is thus excluded here.

C.5-Example 4: Building component in a warm humid climate

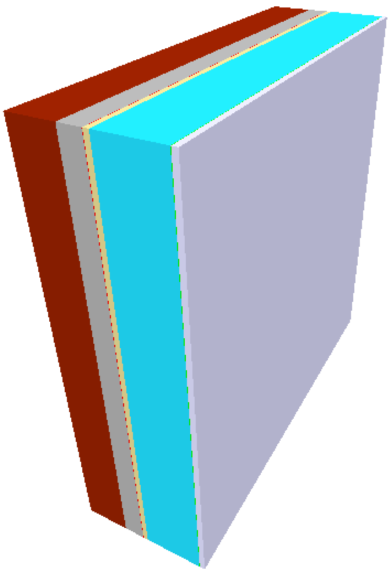
C5_HUMID.trc

In this example a timber framed wall is analysed in warm humid climate conditions. The wall is presented in the figure below.



Key
1 external air
2 brick
3 unventilated cavity
4 permeable membrane
5 plywood
6 insulation
7 vapour control layer
8 plasterboard
9 internal air

Figure 6. Layers and interfaces in timber framed wall



Monthly Mean Climate Data

Month	θe [°C]	RHe [%]	θi [°C]	RHi [%]
January	8.0	63.0	20.0	40.0
February	8.0	63.4	20.0	40.0
March	11.0	64.4	20.0	40.0
April	15.5	69.2	20.0	40.0
May	19.5	76.9	20.0	40.0
June	21.5	84.1	20.0	40.0
July	26.0	85.4	20.0	40.0
August	27.0	82.8	20.0	40.0
September	25.0	80.2	20.0	40.0
October	20.0	70.5	20.0	40.0
November	15.5	68.8	20.0	40.0
December	10.5	66.4	20.0	40.0

Figure 7. Geometry and climate in TRISCO

Moisture Calc Method

☑ Interstitial condensation only at material interfaces

Per cycle keep 1 % of condensation nodes

Minimum drying period 1 day(s)

Vapour permeability of air 2e-10 kg/(m.s.Pa)

Figure 8. Moisture Calculation parameters

Col.		Type	Subtype	Physical flow dir.	Name	λ [W/mK]	ε [-]	μ [-]	θ [°C]	RH [%]	h [W/m²K]	Standard
3		MATERIAL			Vapour control layer	1.000		50000				
4		MATERIAL			Permeable membrane	1.000		200				
15		MATERIAL			Plywood	0.130		90				
129		MATERIAL			Liner	0.208		12				
133		MATERIAL			Insulation	0.040		1.40				
148		MATERIAL			Brick	0.772		8.00				
170		BC_SIMPL	CLIM_E		EXT				CLIM	CLIM	25.00	EN13788
174		BC_SIMPL	CLIM_I	HOR	INT				CLIM	CLIM	7.70	EN13788
192		MATERIAL			Unventilated cavity	0.278		0.01				

Figure 9. Warm humid climate

Figure 10 below compares the accumulated condensation calculated in TRISCO with the results from the standard. A good agreement is found.

Normal occupancy

Month	TRISCO results (interface 5)		table C.3 EN 13788	
	condensation rate g_c [kg/m²]	accumulation rate M_a [kg/m²]	condensation rate g_c [kg/m²]	accumulation rate M_a [kg/m²]
July	0.098244	0.098244	0.0941	0.0941
August	0.115414	0.213658	0.1158	0.2099
September	0.022861	0.236518	0.0211	0.231
Oktober	-0.17433	0.062189	-0.1701	0.0609
November	-0.062189	0*	-0.2563	0
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	0	0	0	0
June	0	0	0	0

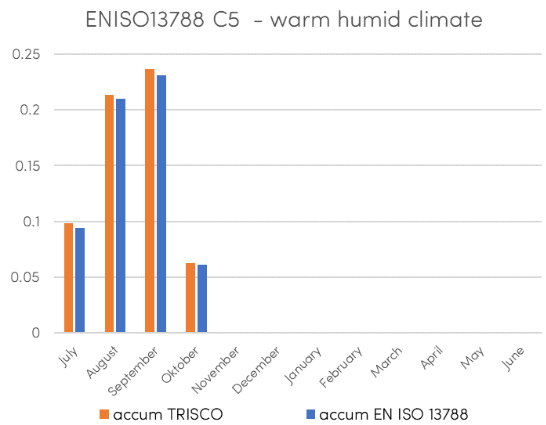


Figure 10. TRISCO results compared with the standard (condensation on interface 5)

C.6-Example 4: Division of a layer with high thermal resistance

C6_HUMID.trc

In this example a wall built from lightweight blockwork with internal insulation is analysed. Both the blockwork and insulation have a thermal resistance greater than 0.25 m²K/W, so the blockwork is divided in 10 layers and the insulation in 2 layers (see section 6.4.1 in EN ISO 13788)

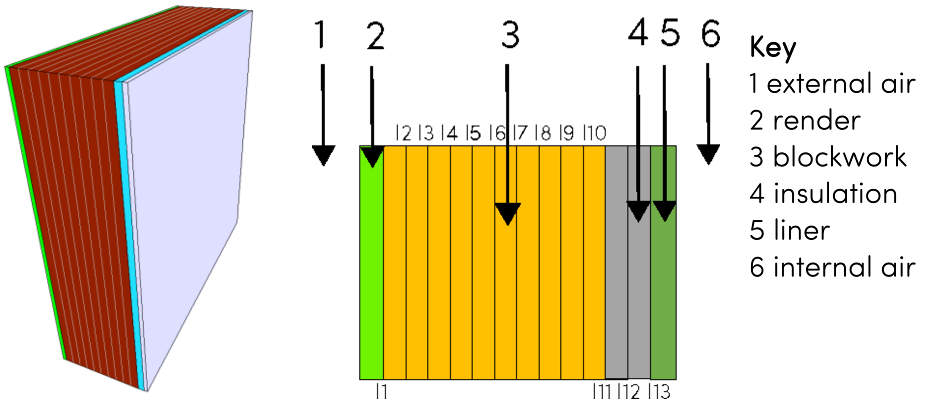


Figure 11. Layers and interfaces

Colours

Col.		Type	Subtype	Physical flow dir.	Geometrical flow dir.	Name	λ [W/mK]	μ [-]	θ [°C]	RH [%]	h [W/m²K]	Standard
3		MATERIAL				Render	0.800	8.00				
129		MATERIAL				Liner	0.565	8.00				
133		MATERIAL				Insulation	0.040	1.00				
148		MATERIAL				Blockwork	0.110	10				
170		BC_SIMPL	CLIM_E			EXT			CLIM	CLIM	25.00	EN13788
174		BC_SIMPL	CLIM_I	HOR		INT			CLIM	CLIM	7.70	EN13788

Figure 12. Material properties and boundary conditions

To allow condensation within construction elements (and not only at interfaces) the following calculation parameters are used.

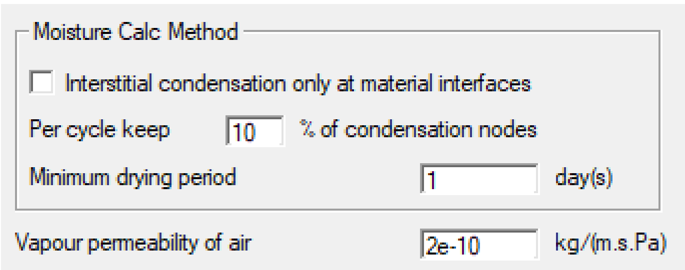


Figure 13. Moisture Calculation parameters

Month	interface 1 + interface 3		table C.12	EN 13788
	condensation rate g_c [kg/m^2]	accumulation rate M_a [kg/m^2]	condensation rate g_c [kg/m^2]	accumulation rate M_a [kg/m^2]
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0.044682	0.044682	0.0498	0.0498
February	0.016891	0.061573	0.0113	0.0612
March	-0.061573	0	-0.0218	0.03056
April	0	0	-0.1863	0
May	0	0	0	0
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0

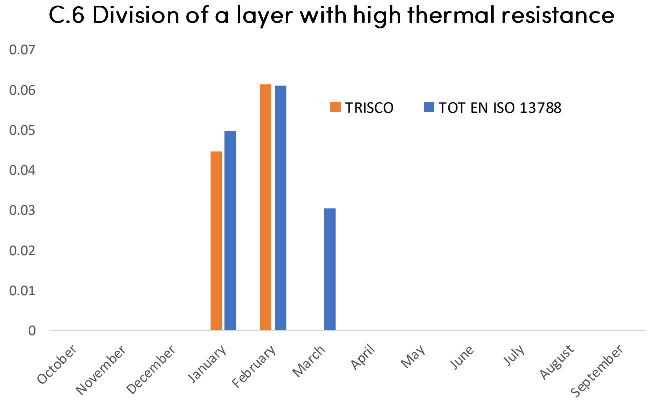
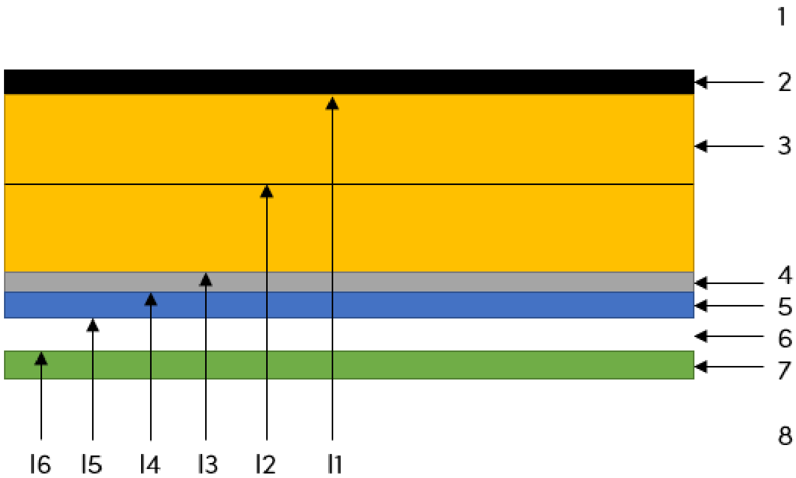


Figure 14. TRISCO results compared with the standard

D – Example of the calculation of the drying of a wetted layer

D_HIGH.trc

This example assumes that the insulation, layer 3 in the flat roof shown in the figure below, has been wetted by precipitation during construction before the installation of the weatherproof membrane. To do this, the insulation layer is divided into two and it is assumed that there is excess moisture content of 1 kg/m^2 at interface I2.
The climate conditions correspond to C.1 with high occupancy.



Key
1 external air
2 membrane
3 insulation
4 vapour check
5 roof deck
6 unventilated cavity
7 liner
8 inside air

Figure 15. Layers and interfaces in roof

The material properties used for each layer in TRISCO are shown in table below:

Colours

Col.		Type	Subtype	Physical flow dir.	Name	λ [W/mK]	μ [-]	θ [°C]	RH [%]	h [W/m²K]	Standard
3		MATERIAL			Vapour check	1.000	75000				
4		MATERIAL			Roofdeck	0.130	10				
32		MATERIAL			Membrane	0.250	6000				
129		MATERIAL			Liner	0.200	12				
133		MATERIAL			Insulation	0.040	1.00				
170		BC_SIMPL	CLIM_E		EXT			CLIM	CLIM	25.00	EN13788
174		BC_SIMPL	CLIM_I	UP	INT			CLIM	CLIM	10.00	EN13788
192		MATERIAL			Air layer	0.625	0.10				

Figure 16. Material properties and initial moisture content in TRISCO

An excess moisture condent of 1 kg/m^2 is introduced by below the roof membrane (interface 1).

Excess Moisture Content

No.			Col. 1	Col. 2	Excess [g/m²]
1			32	133	1000

Figure 17. Initial moisture content in roof construction

interface 1

Month	TRISCO results		table D.2 EN 13788	
	g_c [kg/m²]	M_a [kg/m²]	g_c [kg/m²]	M_a [kg/m²]
			-	0
September	0.984634	0.984634	0.99128	0.99128
Oktober	-0.008442	0.976192	-0.00845	0.98283
November	-0.002081	0.974111	-0.00208	0.98075
December	-0.000125	0.973986	-0.00013	0.98062
January	-0.000075	0.973911	-0.00007	0.98055
February	-0.000727	0.973184	-0.00073	0.97982
March	-0.005212	0.967973	-0.00521	0.97461
April	-0.012664	0.955309	-0.01266	0.96195
May	-0.022534	0.932775	-0.02254	0.93941
June	-0.028201	0.904574	-0.0282	0.91121
July	-0.027347	0.877227	-0.02735	0.88386
August	-0.025384	0.85184	-0.02539	0.85847

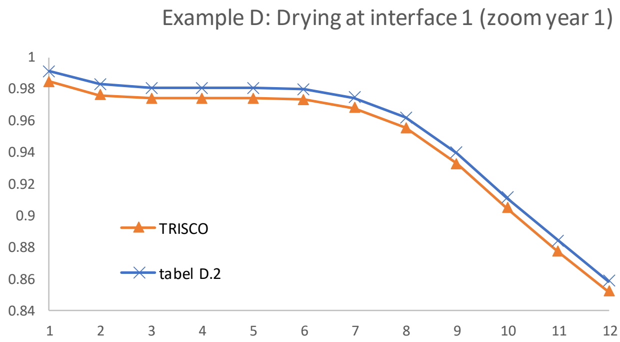


Figure 18. TRISCO results compared with the standard (first year)

The graph below shows that the roof is dried out after a period of 83 months which is in line with the results from EN ISO 13788.

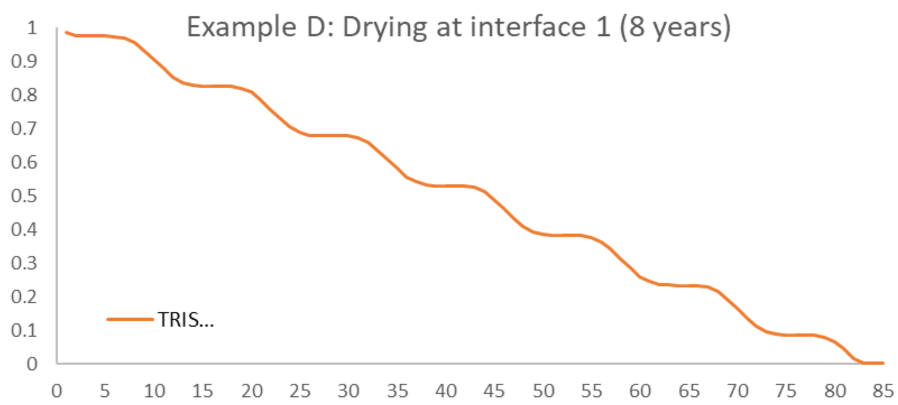


Figure 19. TRISCO results compared with the standard (8 years)