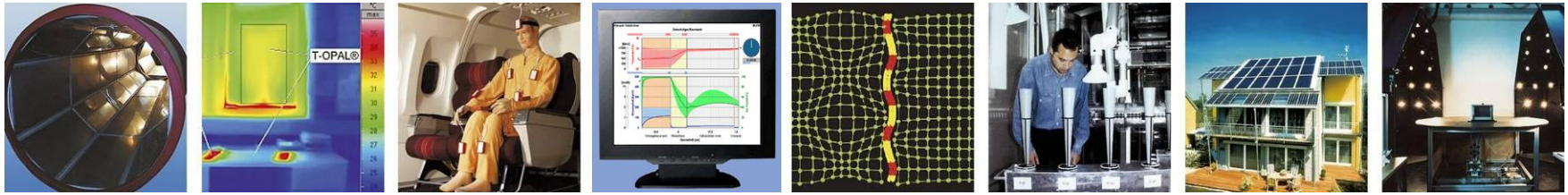


WUFI®

Guideline for the Evaluation and Assessment of hygrothermal Calculation Results

Date: March 2026

Fraunhofer IBP

Content

General Procedure: Evaluation of the Numerical Quality

Dialog: Status of Calculation

This dialog shows a short tabular ***summary of the calculation results***. It is displayed during the calculation and continuously updated. After the calculation, the ***numerical quality of the simulation should be checked*** using the information displayed.

Status of Calculation

Calculation: Time and Date	Feb 11, 2026, 9:50 AM
Begin / End of calculation	Oct 1, 2025 / Oct 1, 2030
Computing Time	0:00:55.435
Current Date/Time	Oct 1, 2030, 12:00 AM

Check for numerical quality

No. of Convergence Failures		**170**	
Sum of diffusive fluxes (left/right)	[kg/m²]	-3.529	-2.525
Sum of capillary fluxes (left/right)	[kg/m²]	0.000	-0.000
Balance (mass vs. sum of surface-fluxes)	**[kg/m²]**	**-0.304**	**-0.307**

Important:
First step after the calculation is always to check the numerical quality of the results using convergence failures / balances!

General Procedure: Evaluation of the Numerical Quality

Number of Convergence Failures:

A ***high number of convergence failures*** indicates a difficult solution of the equations and is usually associated with ***high moisture contents or large amounts of moisture transported***.

The reason for this can be a ***high moisture entry*** or a ***difficult drying***, so e.g. a bad rain protection or vapor-tight layers within the assembly!

Recommendation:
It is often more useful to design the component assembly more favorable than to try to improve the quality of the simulation of the unfavorable component!!

General Procedure: Evaluation of the Numerical Quality

Description of the Convergence Failures:

WUFI® uses an ***iterative process to solve the transport equations***. Sometimes convergence is very slow and WUFI® reaches the maximum allowed number of iterations without the intermediate solutions satisfying the termination criterion.

In this case the iteration is aborted and the result achieved up to that point is compared with somewhat less strict criteria. If these are fulfilled, the result is accepted and WUFI® continues with the next time step. If the ***criteria are not fulfilled***, WUFI® accepts the result anyway and continues the calculation but increases the counter for the ***convergence failures*** by one.

The ***total number of convergence failures*** is a ***first indication regarding the reliability of the results***. However, the fact that a convergence failure was registered says nothing about how large the residual error was when the iteration was aborted.

General Procedure: Evaluation of the Numerical Quality

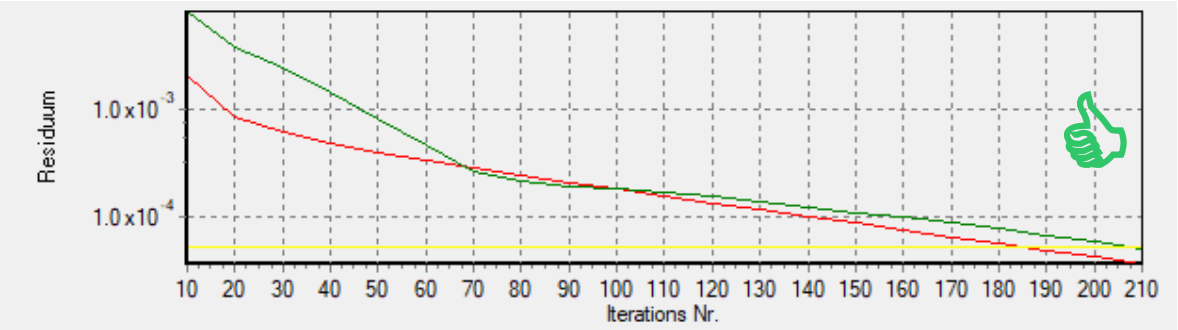
Assessment of the Convergence Failures:

It is possible that the ***termination criteria*** were ***only narrowly missed*** and the ***convergence failure*** is therefore ***negligible***, what is usually the case.

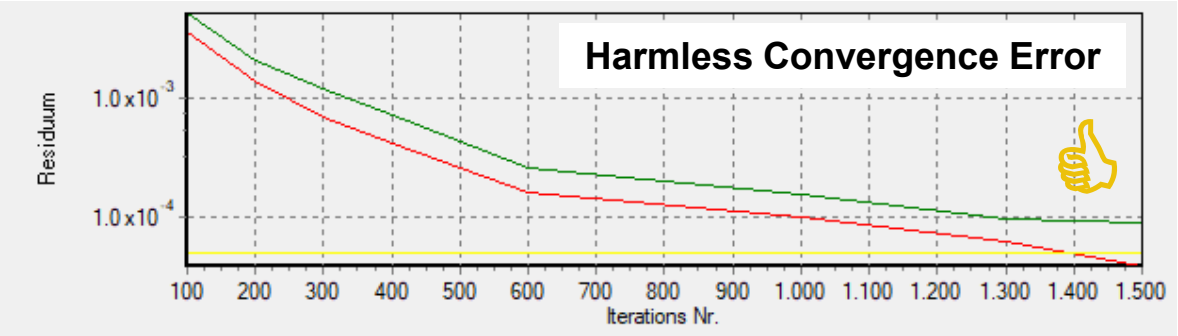
However, it is occasionally also possible that ***numerical instability*** has developed, and the ***iteration steps*** are moving ***further away from the solution***. Often this is noticeable by water appearing or disappearing in the middle of the component without being induced by the boundary conditions. The result is unmotivated jumps in the water content curves and a poor water balance.

Important:
Convergence failures can only be assessed together with the balances!

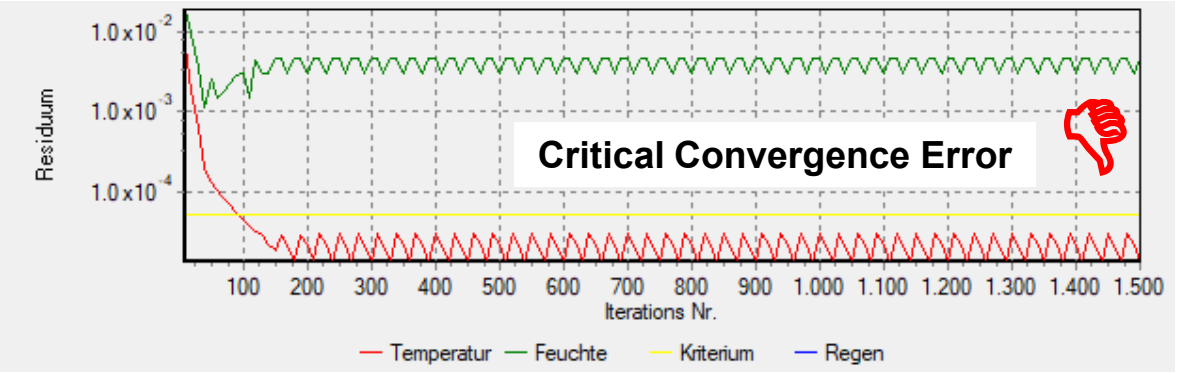
General Procedure: Convergence (Graphs from WUFI® 2D)



Temperature and RH values reach convergence criterion



Converging moisture field, termination after max. number of iterations.
⇨ No or small differences in balances, satisfying accuracy!



Diverging moisture field, termination after max. number of iterations.
⇨ Clear balance differences, not acceptable.

General Procedure: Balances

Evaluation of the balances:

Balance 1 (left): ***Change in the total water content*** in kg/m³ during the calculation period
(negative: drying, positive: moisture accumulation)

Balance 2 (right): Sum of all ***moisture fluxes through the surfaces and released by sources***

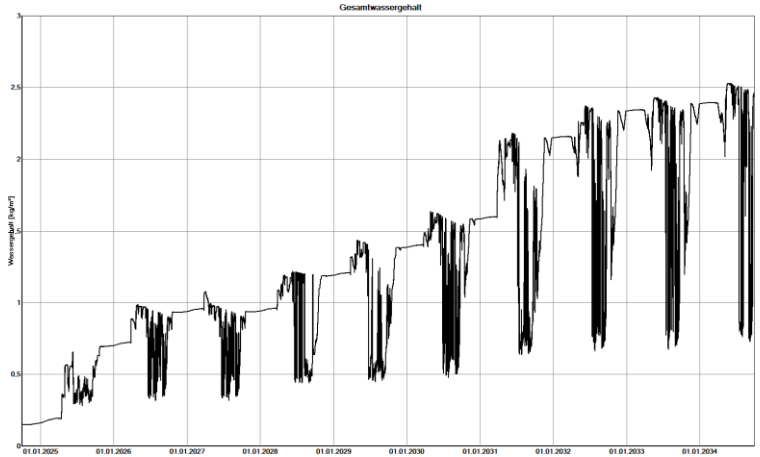
Differences in Balances: Numerical errors or inaccuracies can cause water to „appear“ or to „disappear“ in the assembly
(longer periods cause higher differences in balances)

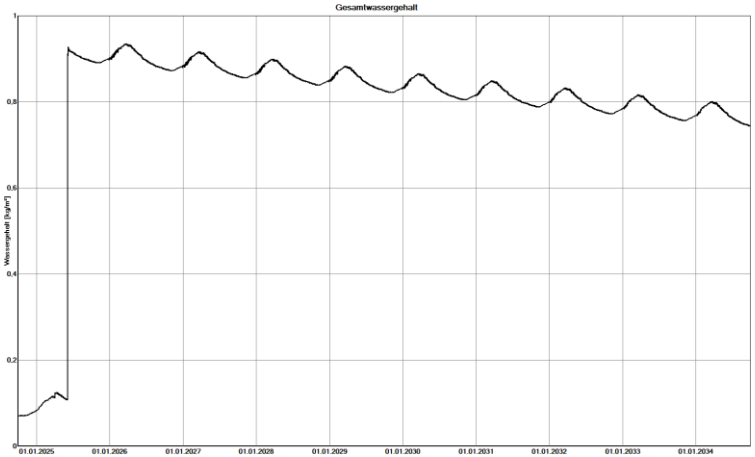
OK: Differences in balances should be zero / small or small relative to the total amount of water taken up or dried out
Generally acceptable rounding accuracy: about ± 10 - 20 g/year

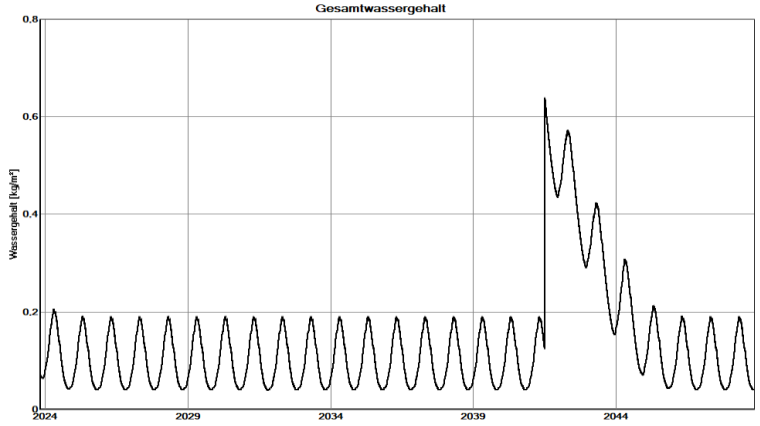
Not acceptable: significant relative and absolute differences in balances

General Procedure: Balances

Larger differences in balances can also be recognized in part by the total water content curve!







Examples of irregular, non-periodic changes in the total water content

⇨ Almost certainly impossible to evaluate meaningfully!

What to do in case of convergence failures / differences in balances?

Select a finer grid:

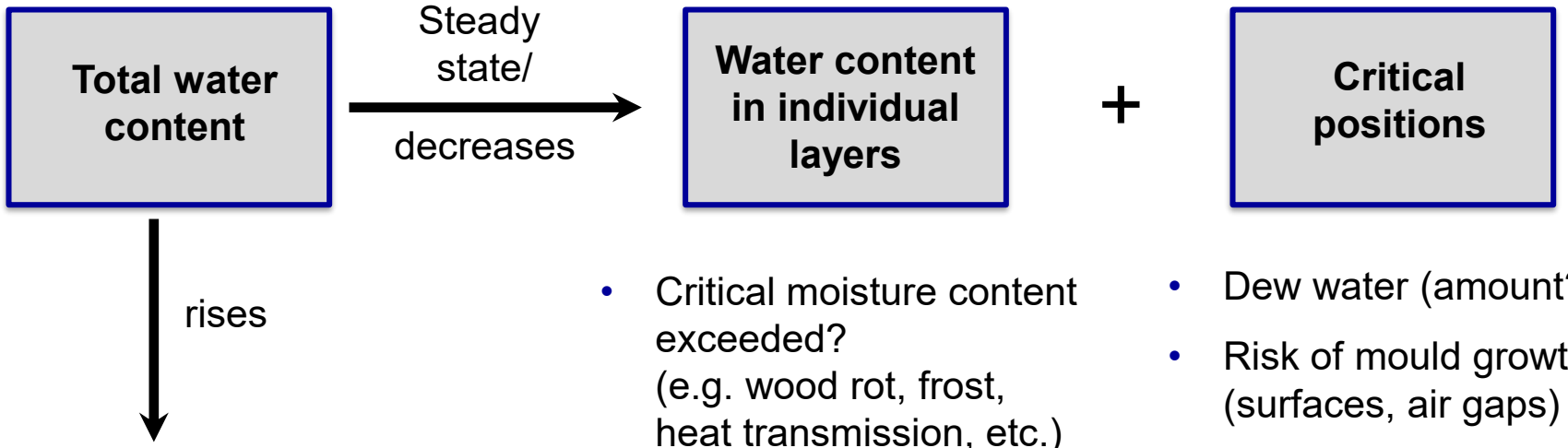
Normally, the use of the automatically generated grid is sufficient. In ***exceptional cases***, however, an ***even finer grid structure may be required***.

To do this, you can select „user-defined“ and enter the desired number of grid elements, which will then be distributed over the component by the automatic grid generator.

Switch on adaptive time step control:

If the adaptive time step control is enabled, WUFI® automatically switches to ***shorter time steps*** as soon as numerical problems are identified. The numerical problematic calculation step is repeated with shorter time steps; if necessary, these time steps are further subdivided. ***In many cases***, a ***calculation*** which produces numerous convergence failures or a poor numerical balance ***can be improved***.

General Procedure: Principle of Evaluation „coarse to fine“:



1. Extend calculation period
2. Start with higher initial water content
3. In case of long-term increase:
   Construction fails due to accumulation of moisture

- Critical moisture content exceeded?
  (e.g. wood rot, frost, heat transmission, etc.)
- Increases over many years → accumulation by redistribution

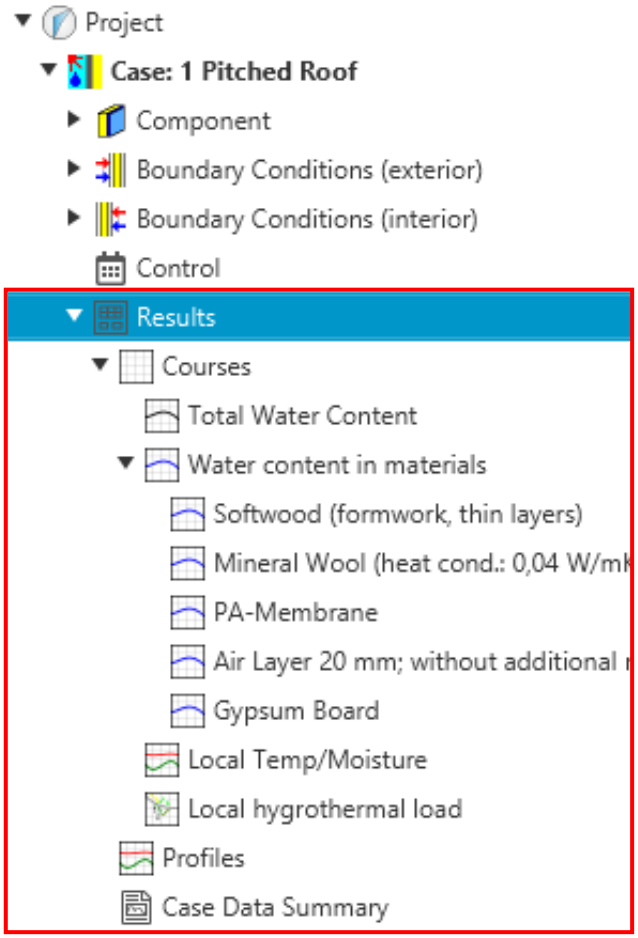
- Dew water (amount?)
- Risk of mould growth (surfaces, air gaps)
- Wood decay
- Risk of frost damage
- Corrosion
- etc.

Tools for Result Evaluation – Quick Graphs

Quick overview over the calculation results:

Displayed in the order of practical evaluation:

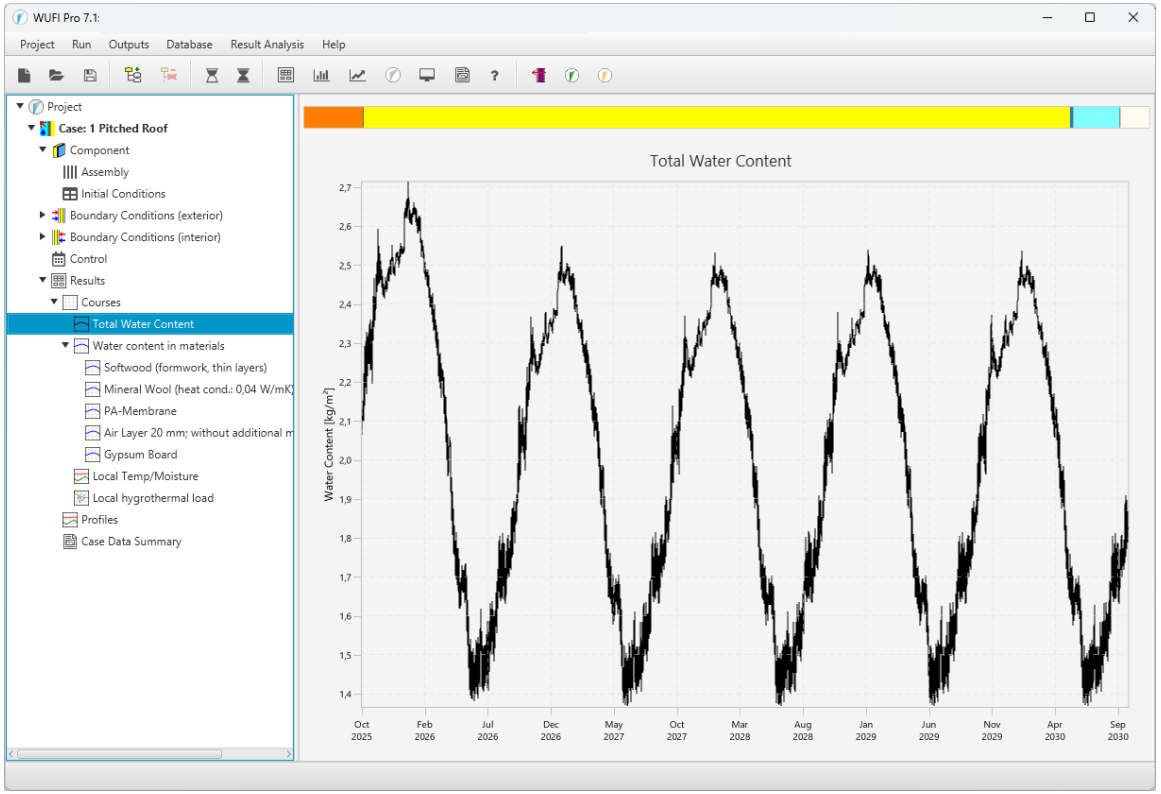
- Total water content
- Water content in the individual material layers
- Local temperature / relative humidity
- Local hygrothermal load



Tools for Result Evaluation – Quick Graphs

Total water content in [kg/m²]

- Water content of a component per m² component area
  (thicker constructions tend to contain more moisture than thin ones)



Usually only qualitative assessment of the moisture balance!

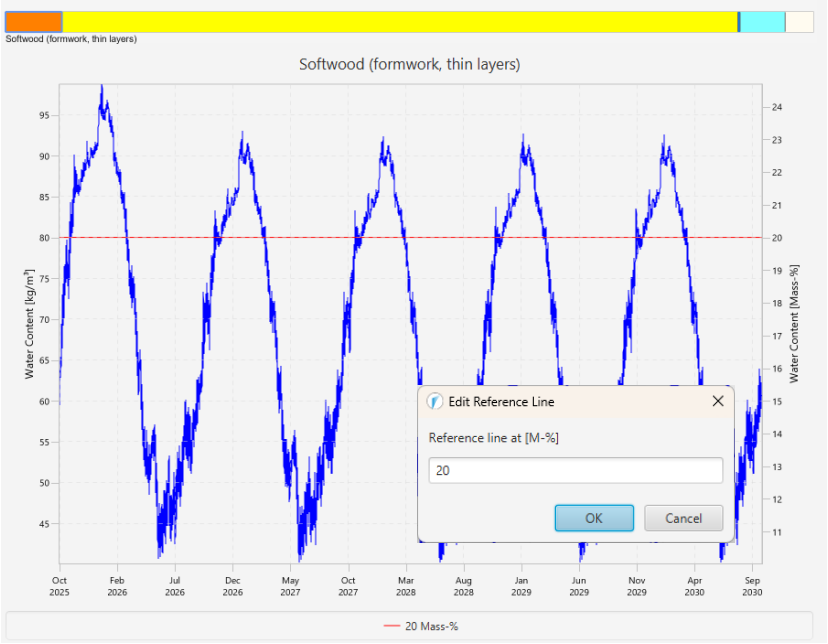
Tools for Result Evaluation – Quick Graphs

Water content in layer in [kg/m³] or [M.-%]

- Qualitative assessment of the moisture balance of individual materials / layers
- Quantitative assessment of the moisture level achieved
- Divide thick layers at the boundaries if necessary

Evaluation regarding e.g.:

- Wood decay (18 % by mass for wood-based materials and 20 % by mass for solid wood)
- Frost damage
- Transmission heat losses
- etc.



According to DIN 4108-3 [1] and WTA 6-8 [2], not only the whole layers but also the 1 cm thick areas on the critical side must be evaluated.

Tools for Result Evaluation – Quick Graphs

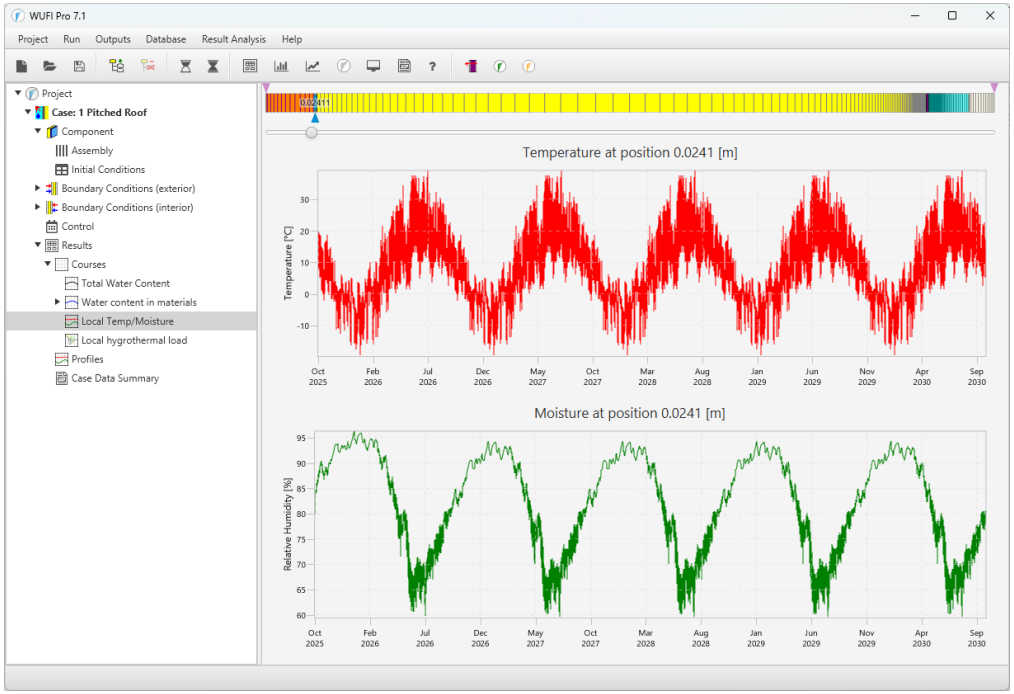
Local temperature and relative humidity

- Qualitative assessment of the moisture behavior
- Quantitative assessment of the achieved moisture level

Evaluation regarding e.g.:

- Condensation water (100 % RH)
- Mould growth
- Frost damage
- Risk of corrosion
- etc.

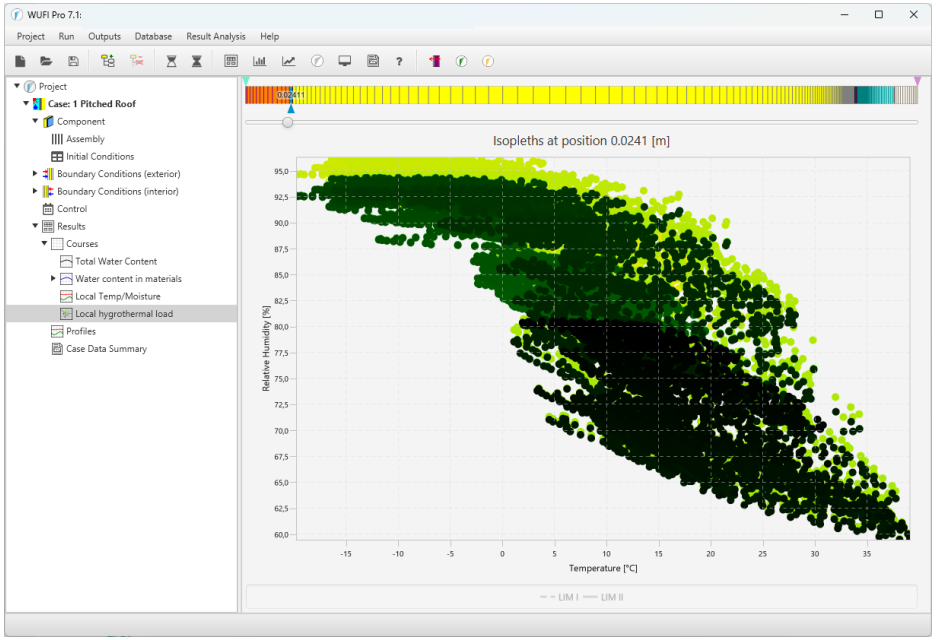
Select different positions using the slider or left mouse click. Set monitor positions with a right mouse click.



Tools for Result Evaluation – Quick Graphs

Local hygrothermal loads

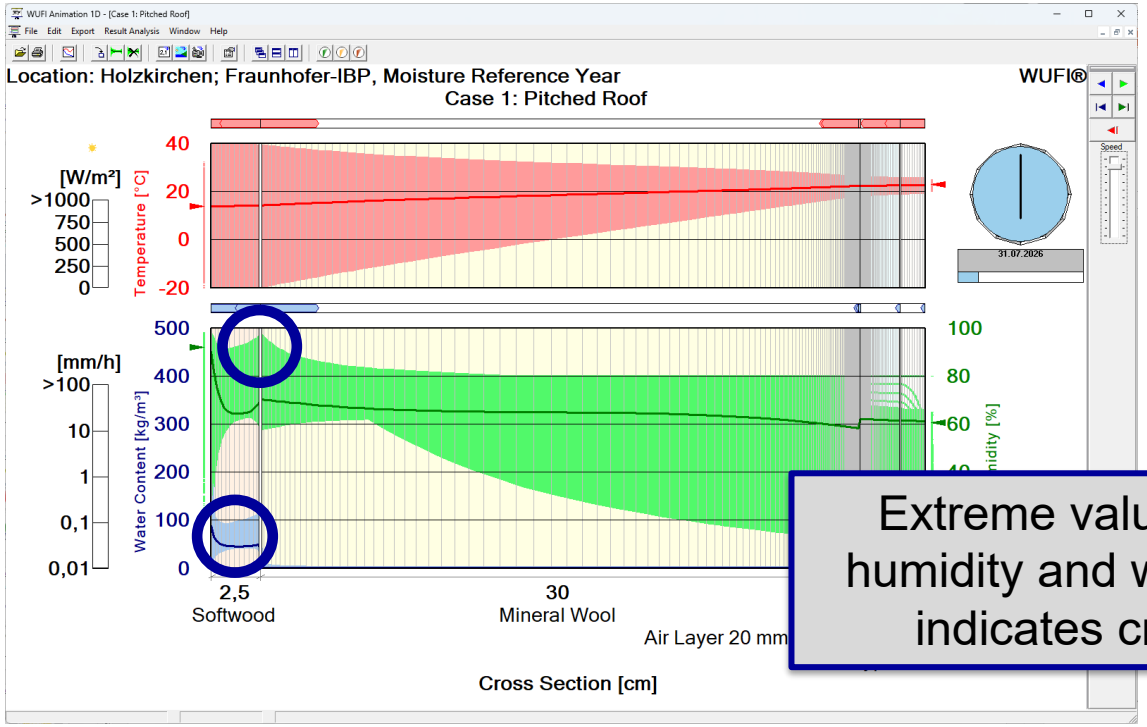
- Visualization of the occurring combinations of temperature and relative humidity
- Qualitative color gradient of the points from yellow (start of calculation) to black (end of calculation)
- Exceeding the LIM curves on the inner surface: possible risk of mould growth → further evaluation with WUFI® Bio required
- Evaluation of critical limits concerning strength loss or durability if available



Tools for Result Evaluation – WUFI® Animation

Presentation of the calculated profiles as a movie:

- Sequence of the hourly calculated profiles for temperature, relative humidity and water content as a motion picture
- Clear representation of the transport and storage processes
- Easy identification of critical positions



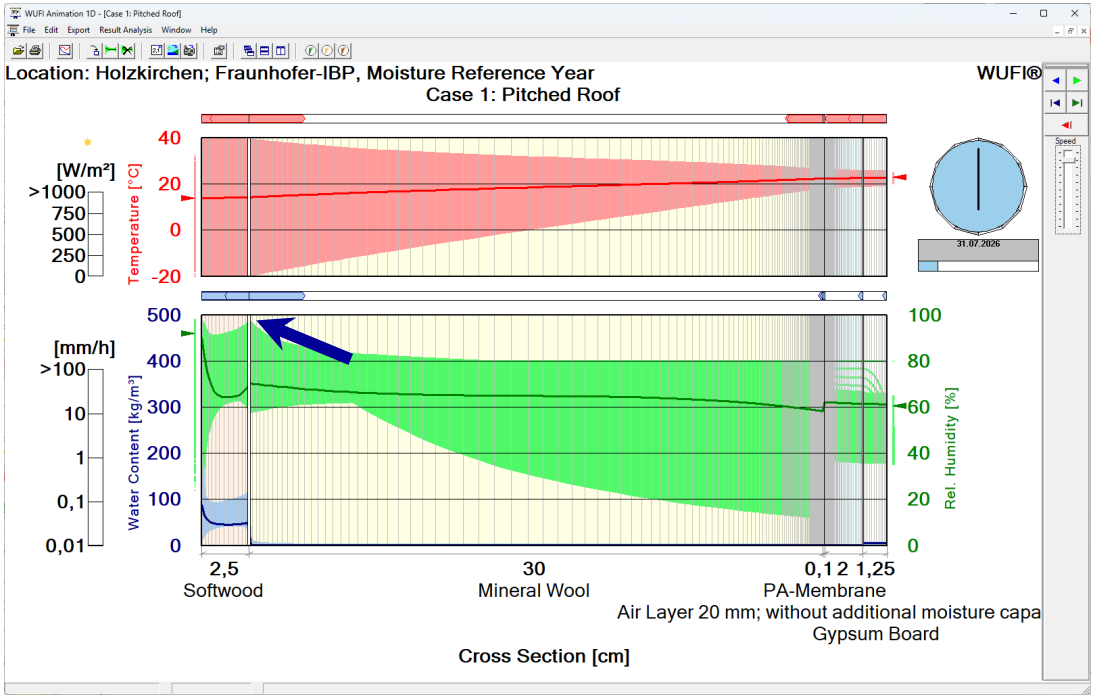
Extreme values in the relative humidity and water content often indicates critical positions.

Tools for Result Evaluation – WUFI® Animation

Additional extraction of a monitor position:

- Plotting of the course of temperature, relative humidity and water content for every grid element is possible.

- Procedure:
  1. Stop motion picture
  2. Right mouse click
     → „Create course“
  3. Select desired position/grid element



Note:
Does not work at the end of the animation – jump back a time step if necessary!

Tools for Result Evaluation – WUFI® Animation

Additional monitor position:

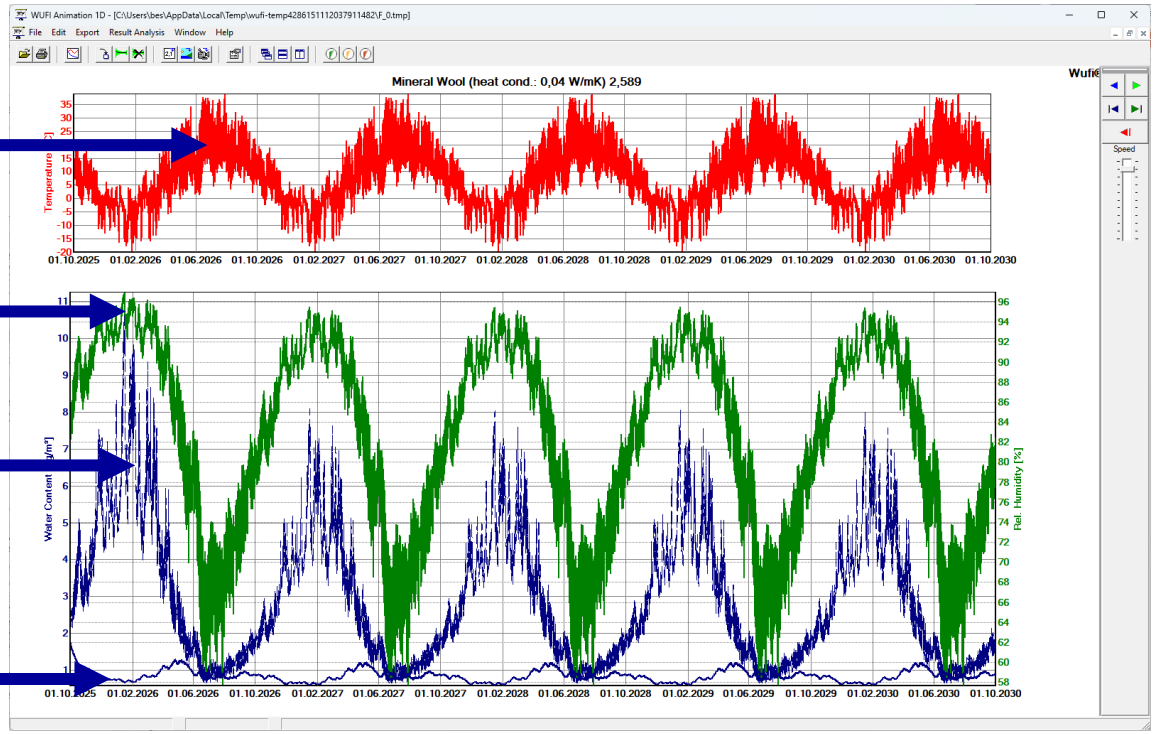
- Display of the course of temperature, relative humidity and water content in the grid element selected

temperature

relative humidity

water content in the grid element (dotted line)

Water content in the total layer

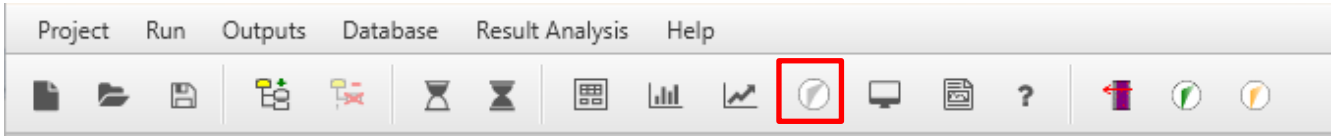


Tools for Result Evaluation – WUFI® Graph

Open WUFI® Graph:

- Save WUFI® Pro project file

- Menu: „Result analysis“ → „WUFI® Graph“
  or
  WUFI Graph® - Button



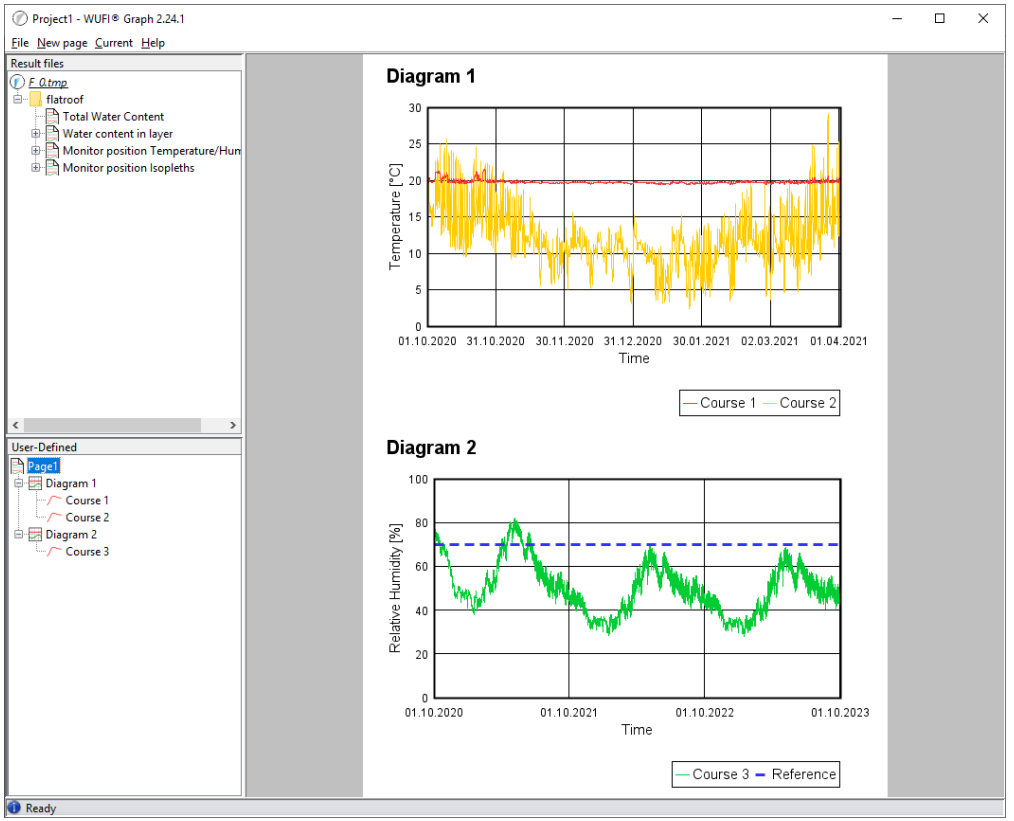
- All cases saved and calculated in the project file are opened in WUFI® Graph.

Tools for Result Evaluation – WUFI® Graph

Possibilities of evaluation in WUFI® Graph:

- In the “Result Files“ area the quick graphs from WUFI® Pro are displayed as predefined diagrams.

- In the “User-Defined“ area, you can create your own pages with result diagrams:
  - Temperature
  - Relative Humidity
  - Water Content
  - Isopleths
  - Averaged Flux Density
  - Flow
  - WTA 6-8
    (Evaluation of wood moisture)

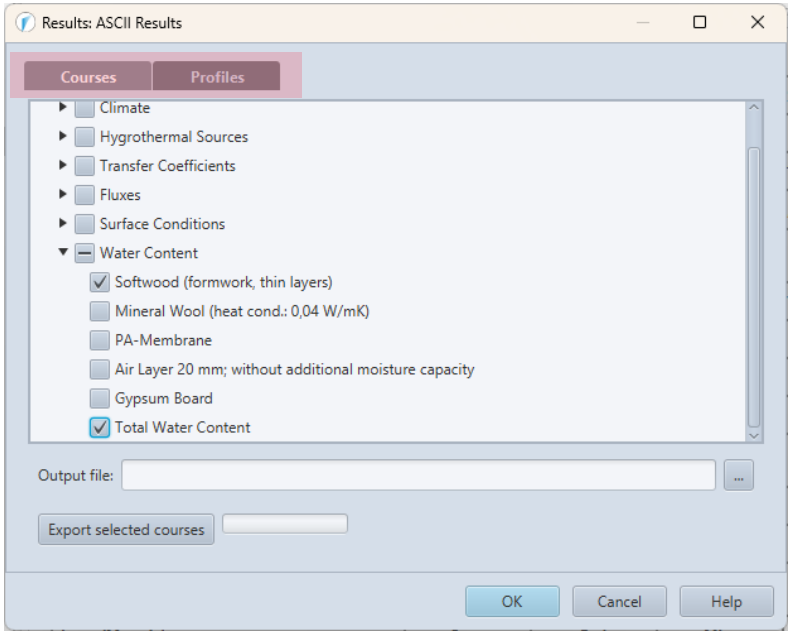


Tools for Result Evaluation – ASCII-Export

Output of the calculation results:

- Menu: „Outputs“ → „ASCII-Export“
- Output of the calculation results as ASCII file for further evaluation e.g. in Excel…

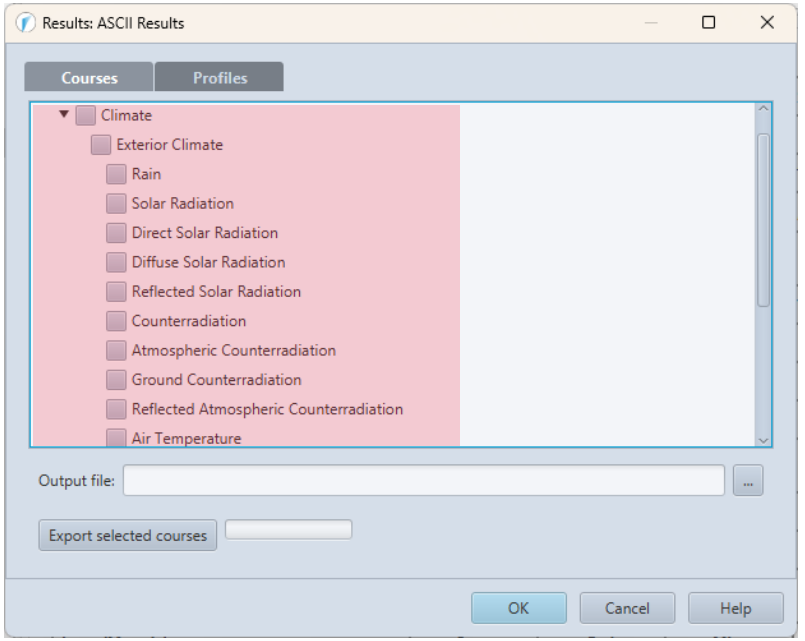
- Courses over time in hours (first column)
- Profiles over the distance of the respective grid element in millimeters from the left side of the assembly (first column)
- Result elements in the same order as in the selection list



Tools for Result Evaluation – ASCII-Export

Output of boundary conditions:

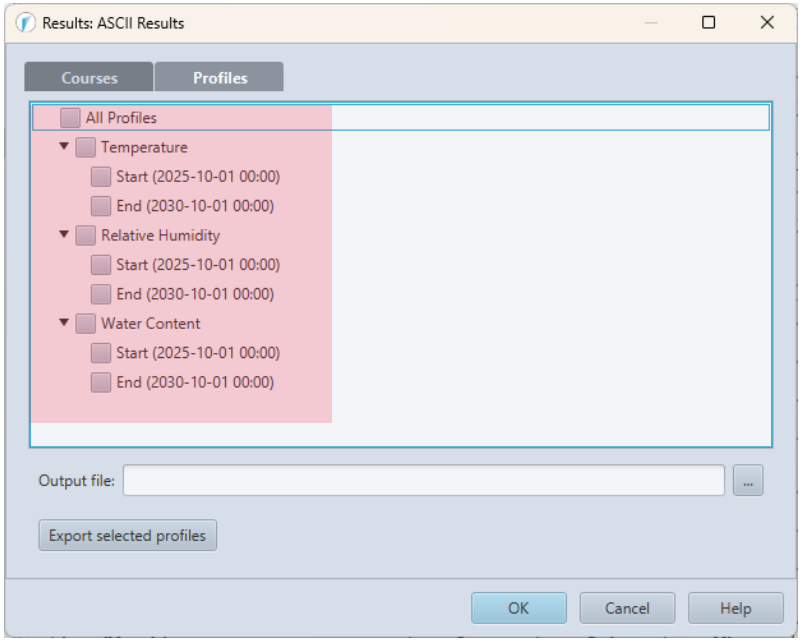
- Output of ***boundary conditions***:
  - basically ***possible*** (e.g. solar radiation on the component surface, outside air temperature etc.)
  - ***blocked*** (elements are greyed out), if a climate file was used for the calculation which is only intended for use with WUFI® for license reasons



Tools for Result Evaluation – ASCII-Export

Output of Profiles:

- ***Temperature-*** and/or ***water content profile*** of a calculation step can be used as the initial temperature- and/or initial water content profile for a further calculation



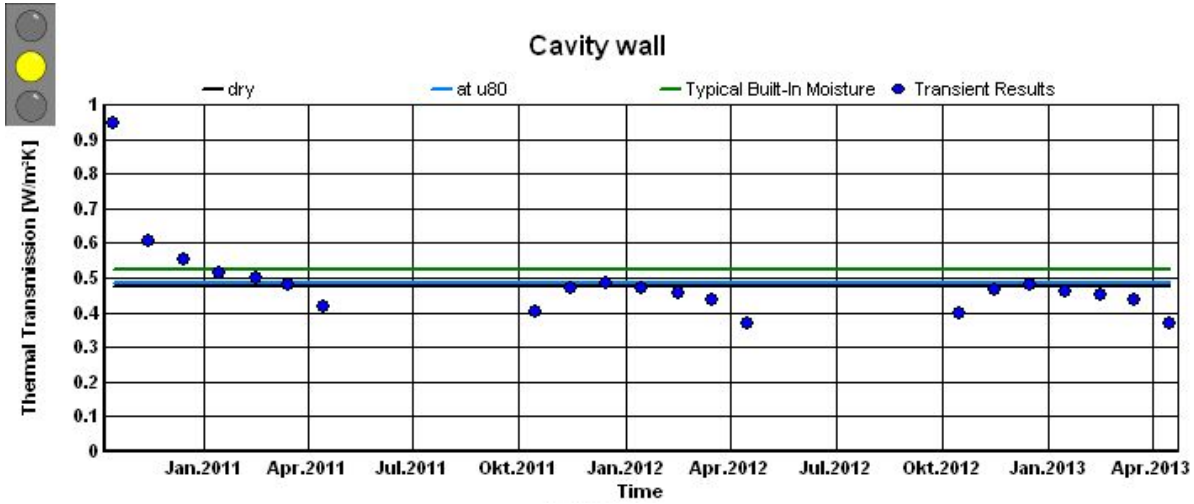
Tools for Result Evaluation – Post Process Modules

What are post process modules?

- WUFI® calculates the hygrothermal conditions in the component but does not evaluate them.
- Post process modules are programs to which WUFI® can transfer the results of the hygrothermal calculation for further analysis.
- The modules are installed additionally or can also be programmed and made available by third parties.
- Available post process modules:
  - Thermal Transmission (transient U-value)
  - WUFI® Bio
  - WUFI® Corr
  - WUFI® FinMould

  https://wufi.de/en/software/wufi-add-ons/

Thermal Transmission – Options for evaluation



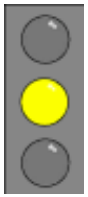
- Allows the ***transient evaluation of thermal transmission*** taking into account the influence of humidity, radiation, latent heat, etc.
- In the case of high radiation gains, the transient U-value may also become negative under certain circumstances, if the outside surface becomes warmer than the room air temperature despite a low outside air temperature.
- The ***evaluation*** is only useful ***during the heating period.***

Thermal Transmission – Evaluation with traffic light system

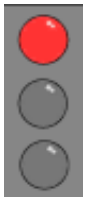
The traffic light limit values for U_1 and U_2 are based on the current and old minimum thermal insulation for hygienic reasons regulated in the German Standard DIN 4108-2

- $U_1 \leq 0{,}73$ W/m²K or $R_1 \geq 1{,}2$ m²K/W → for mould-free conditions (Version 2003)
- $U_2 \leq 1{,}39$ W/m²K or $R_2 \geq 0{,}55$ m²K/W → for condensation-free conditions (Version 1981)

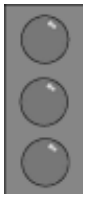
All evaluated months have a thermal transmission below U_1.



All evaluated months have a thermal transmission below U_2, but at least one is above U_1.



At least one of the evaluated months has a thermal transmission exceeding U_2.



Evaluation period is less than one year.

Values for other climatic conditions only useful to a limited extent!!
U-values can be adjusted in the ini-file.

Tools for Result Evaluation – Post Process Modules

WUFI® Bio

- For the evaluation of mould growth under transient hygrothermal conditions.
- The moisture balance of the mould spores is modeled and compared with the critical water content where spore germination occurs.
- If germination occurs, the subsequent level of the mould infestation can also be estimated by comparison with growth curves.

More detailed information on this can be found in the
Guideline for assessing the risk of mould growth with WUFI®

Tools for Result Evaluation – Post Process Modules

WUFI® Corr

- Allows the prediction of the corrosion risk of metal components in mineral building materials.
- The temperature and moisture conditions at the metal surface as well as the chemical milieu of the surrounding materials are taken into account.
- It allows the evaluation of preventive restoration measures, the refurbishment of listed buildings and a safe and durable design of new building components.

More detailed information on this can be found in the
Guideline for assessing the risk of corrosion with WUFI® Corr

Evaluation Criteria

General:

- The results of a hygrothermal simulation are the courses over time of temperature, humidity and water content in the different material layers.
- The results can be evaluated individually and have to be assessed depending on the materials used.
- ***Evaluation criteria***:
  1. Moisture balance based on the total water content
  2. Moisture limit values (layers, positions)
     - Wood moisture
     - Increase in thermal conductivity
     - Condensation in fibre insulation
     - Mould growth
     - Risk of frost
     - Risk of corrosion

Evaluation Criteria – Moisture Balance based on Total Water Content

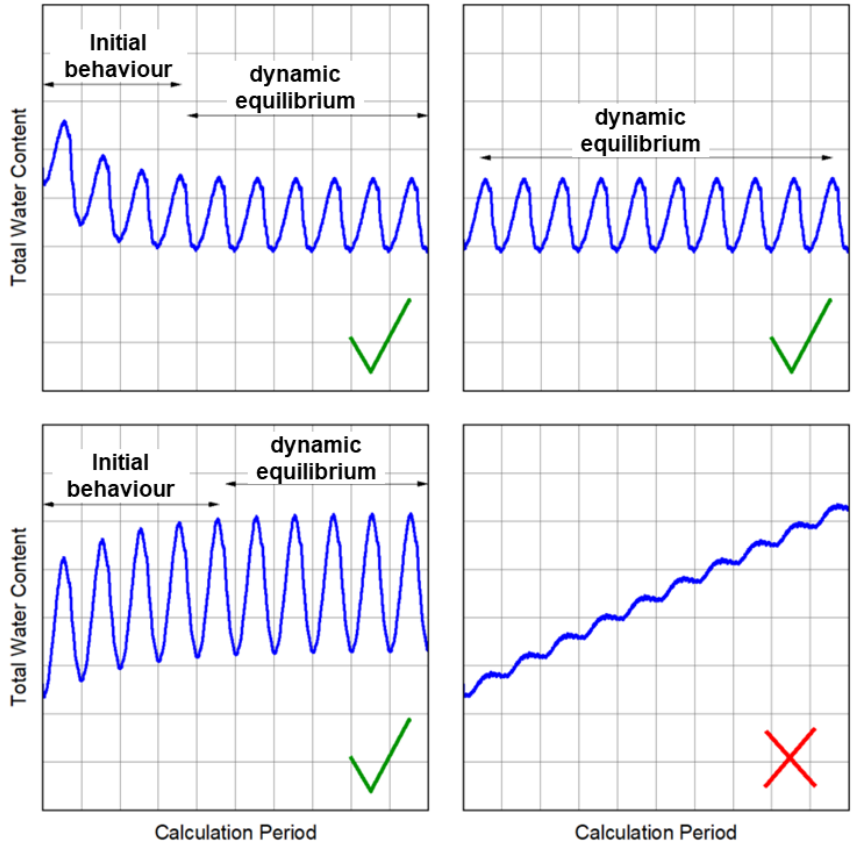
Hygrothermal behavior of a construction:

- ***No excessive amount of moisture should accumulate*** in the structure ***over the long-term.***
- Initial increases or decreases in water content are normal if the specified initial water content is above or below the water content of the resulting dynamic equilibrium.
- According to DIN 4108-3 [1], the water content reaches the dynamic equilibrium when the change in the total water content and in the individual layers is < 1 % compared to the previous year.
- ***Seasonal variations*** in total water content are also ***normal*** to a limited extent.
- Seasonal differences in the water content in the individual layers can be caused by the variations in the total water content or by periodic redistributions within the component.

Evaluation Criteria – Moisture Balance based on Total Water Content

Evaluation of the total water content

- ***Decreasing***: Component dries
- ***No change to last year***: dynamic equilibrium is reached
- ***Short-term increase also OK***: humidity level in dynamic equilibrium is higher than the assumed initial moisture
- ***Long-term increase***: permanent moisture accumulation in the construction (higher wetting than drying – may be acceptable at low levels if no critical moisture conditions are reached during lifetime)



Evaluation of the moisture balance is only the first step,
the analysis must always include the water contents in the layers!!!

Evaluation Criteria – Moisture Limit Values: Wood Moisture

Established limit values:

- ***Limit values according to DIN 68800 [4]*** to prevent wood decay and strength loss:
  - 20 M.-% for wood
  - 18 M.-% for wood-based materials

  The limit values contain certain margins – only from a fiber saturation above about 25 to 30 M.-% can the fungi extract enough moisture from the wood to allow degradation of the material.

- ***WTA-Guideline 6-8 [2] or German Standard DIN 4108-3 [1]***:
  Includes a model for a more precise assessment of the wood rot risk as a function of relative humidity and the simultaneously occurring temperature.

Evaluation Criteria – Moisture Limit Values: Wood Moisture

Evaluation according to WTA-Guideline 6-8 [2] resp. DIN 4108-3 [1]

- According to the WTA-Guideline 6-8 [2], the evaluation is based on two criteria:

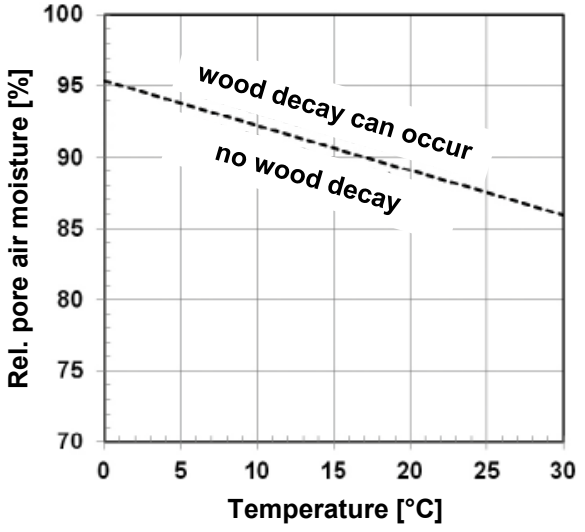
1. The ***evaluation with regard to wood-destroying fungi*** is carried out for wood on the basis of the average pore air moisture content of the relevant critical 10 mm layer.

2. For the ***evaluation of the constructive aspects*** the average wood moisture content of the entire material layer is used.

Evaluation Criteria – Moisture Limit Values: Wood Moisture

Wood rot risk according to WTA 6-8 [2] resp. DIN 4108-3 [1]

- The evaluation of the wood rot risk according to WTA 6-8 applies to solid wood products (e.g. solid construction wood, glued or dowelled solid wood products, solid wood formwork, three-layer panels, glued laminated timber, solid wood panels).
- For wood-based materials and wood fibre insulation, the general limit of 18 M.-% from DIN 68800 [4] can be used. Alternatively, the manufacturer can guarantee up to which wood moisture content his product may be used.
- The relative pore air moisture must not exceed 95 % at 0 °C and 86 % at 30 °C on a daily average in the most critical 10 mm layer.

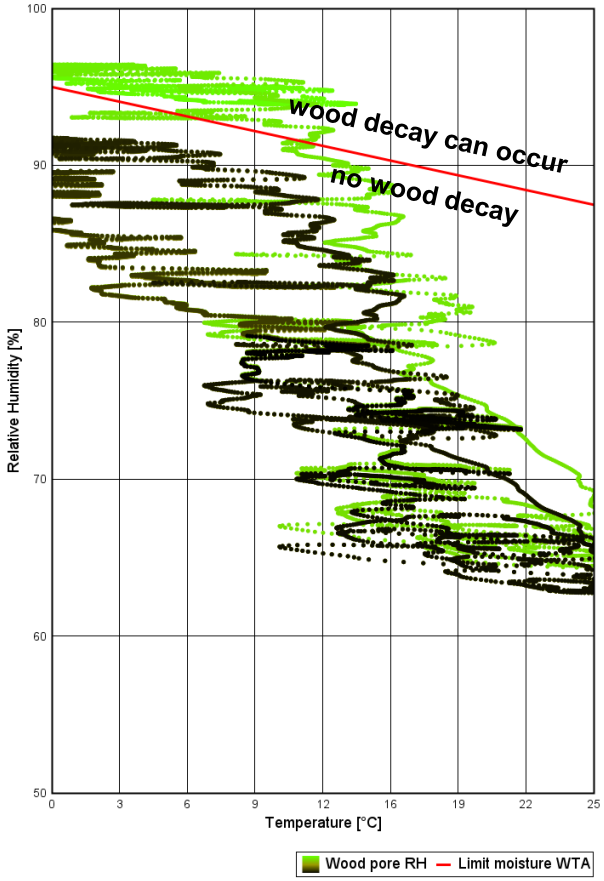


This evaluation is possible with WUFI® Graph.

Evaluation Criteria – Moisture Limit Values: Wood Moisture

Wood rot risk according to WTA 6-8 [2] resp. DIN 4108-3 [1]

- Direct evaluation with WUFI® Graph



Evaluation Criteria – Moisture Limit Values: Wood Moisture

Load-bearing capacity (strength of materials)

- Wood and wood-based materials are classified in service classes according to EN 1995-1-1 [5]. The usability according to these classes must be ensured.

- In general, the following limit values must not be exceeded for load-bearing components to ensure the declared properties:

	Solid wood	Wood-based materials
Permissible humidity (permanent)	20 M.-%	18 M.-%
Permissible humidity (during dry-out in the 1st year)	22 M.-%	20 M.-%

Daily mean value of the wood moisture of the entire material layer!

Evaluation Criteria – Moisture Limit Values: Wood Moisture

Usability

- Deformations of the overall construction e.g. due to seasonal moisture changes or an uneven moisture distribution in components.

- Deformations must remain within reasonable limits. Reference to limit values can be found in various standards such as e.g. EN 1995-1-1 [5].

Evaluation Criteria – Moisture Limit Values: Natural fibre insulation

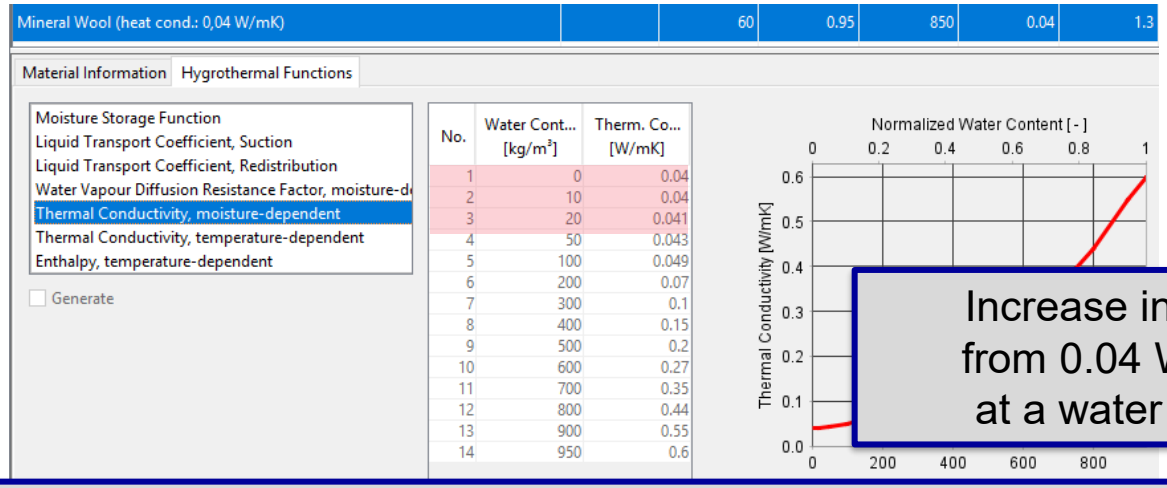
Current state of science:

- Research projects carried out in recent years [6], [7] have shown that many, but not all, fibre insulation materials made from wood and natural fibers are more resistant than solid wood.
- If this has been proven or confirmed by the manufacturer, the limit curves according to WTA 6-8 [2] can also be used for the respective material.
- A post-processor for the transient assessment of the risk of decay is currently being developed and will then enable an even more accurate assessment, which, however, will be of reduced certainty and therefore particularly useful for individual cases and less so for normal planning.
- A test is required to classify the decay resistance of specific materials.

Evaluation Criteria – Moisture Limit Values: Increase Thermal Cond.

Increase of thermal conductivity in moisture-resistant insulation materials:

- Moisture absorbed via diffusion can lead to an increase in the thermal conductivity of moisture-insensitive insulation materials (rigid foam insulation or mineral fiber).
- This dependency is usually stored in the material data so that reasonable maximum values can be derived from it.



Increase in thermal conductivity from 0.04 W/mK to 0.041 W/mK at a water content of 20 kg/m³.

Unavoidable moisture inputs possibly can be compensated by greater insulation thicknesses if the moisture has no other negative effects.

Evaluation Criteria – Moisture Limit Values: Interstitial Condensation

Risk of interstitial condensation runoff:

- Condensation in building components can develop in vapor-permeable materials (air, fibre insulation) adjacent to water- and vapor-tight materials (e.g., roofing membrane, vapor barriers, etc.).

- If the amount exceeds a certain level, the condensation water can run off and cause problems in other areas of the building components – this must be avoided!

Assessing the risk of interstitial condensation runoff according to
Guideline for assessing the risk of interstitial condensation runoff

Evaluation Criteria – Moisture Limit Values: Mould Growth

Mould risk assessment:

- Mould growth on the interior surface and in cavities at material boundaries is possible with higher humidity conditions.

- Assessment of the interior surface using the limit isopleths, which represent the minimum growth conditions.
  - Conditions remain below the limit curves:
    mould growth is not possible
  - Conditions exceed the limit curves:
    risk depends on the duration and degree of the exceedance
    → more precise evaluation possible with WUFI® Bio

Assessing the risk of mould growth according to
Guideline for assessing the risk of mould growth with WUFI®

Evaluation Criteria – Moisture Limit Values: Risk of Frost

Risk of frost in different materials:

- Due to the volume expansion of the freezing water, ***high water contents*** can weaken and ***damage a porous building material when a greater number of freeze-thaw cycles occur***.

- ***Frost-resistant materials*** such as plasters, masonry, concrete:
  - Water contents up to free water saturation usually acceptable
  - Please note: high moisture levels increase the risk of algae and mould on the outer surface.

- ***Non-frost-resistant materials***:
  - These must not exceed certain limit water contents during the frost period. However, no limit values for critical combinations of water content and temperature are known for most materials.

Evaluation Criteria – Moisture Limit Values: Risk of Frost

Assessment of the risk of frost according to WTA 6-5 [8]:

- Criterion according to WTA-Guideline 6-5 (for interior insulation):

  non-frost-resistant materials should not exceed a degree of moisture penetration of 30 % (i.e. 30 % of the maximum water content w_{max}). Higher levels of moisture penetration are permissible if the relative humidity of the pore air remains below 95 %.

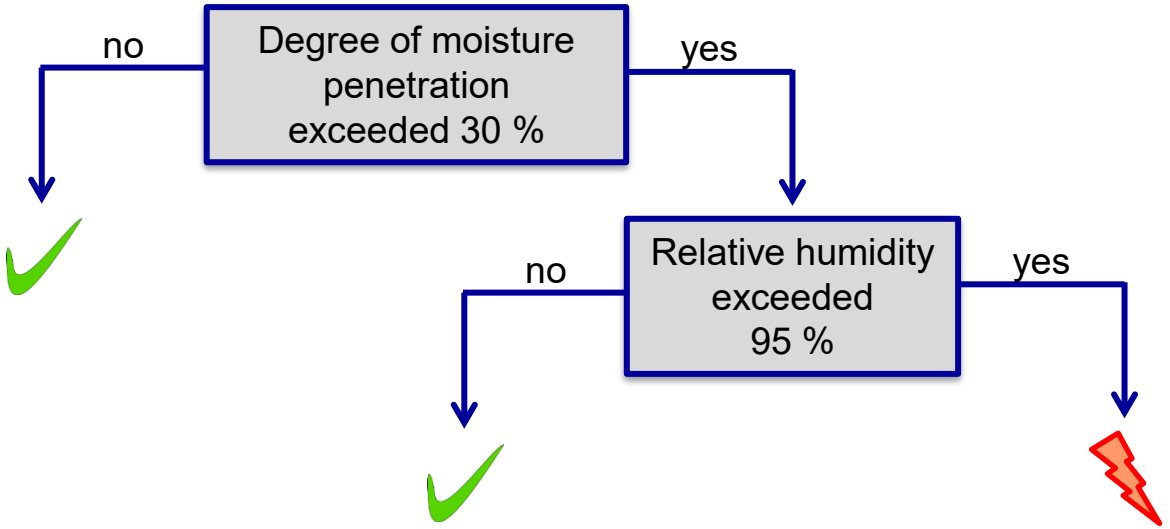
  → according to current information, this means that frost damage can be excluded for materials that are sensitive to frost.

- For ***materials with a high porosity*** (e.g. hollow bricks), the degree of moisture penetration of 30 % refers to the maximum water content in the brick shard itself – the voids must not be taken into account in the porosity.

Evaluation Criteria – Moisture Limit Values: Risk of Frost

Procedure for assessing the risk of frost:

- Evaluation of the water content at the most critical position of the frost-sensitive material.
- Find critical position / grid element using WUFI® film: position with high moisture content where the temperature is below 0 °C at the same time
- In the WUFI® film:
  right mouse button → Create Course
  then select the critical grid element



Evaluation Criteria – Moisture Limit Values: Risk of Frost

Practical rules:

- Use frost-resistant materials in areas with high humidity and frost exposure!

- For interior insulation and unknown frost resistance of the existing wall, improve rain protection to such an extent that the moisture level does not rise or rises only minimally due to additional insulation.

Evaluation Criteria – Moisture Limit Values: Risk of Corrosion

Corrosion risk assessment:

- Corrosion of metallic components, which are embedded in a mineral surrounding material, at high humidity (e.g. reinforcing steel in the concrete after its carbonation).

- Quantification of corrosion progress depending on temperature and relative air humidity in different mineral building materials.

Assessing the risk of corrosion according to
Guideline for assessing the risk of corrosion with WUFI® Corr

Further Evaluation Criteria

Other possible evaluation criteria:

- Moisture-related softening
- Chemical behaviour
- Hygrothermal durability
- …

Since these are distinctly material-specific processes, an evaluation is only possible if the manufacturer can provide corresponding correlations or limit values.

Evaluation Criteria – Summary

Total water content and water content in single layers:

In dynamic equilibrium status or decreasing
normally not permanently increasing (exception, if unproblematic over whole service life)

Mould growth on interior surfaces:

Level 1: < 80 % RH
Level 2: < material specific LIM curve
Level 3: transient evaluation with WUFI® FinMould or WUFI® Bio

Moisture content in wood or natural materials/insulations:

Level 1: < 20 % by mass (solid wood) resp.
< 18 % by mass (load bearing wooden materials), whole layer
Level 2: limit curve acc. to WTA-6-8 [2] (solid wood), critical 10 mm area
Level 3: transient evaluation with WUFI® Decay (available soon)

Corrosion of metal elements in mineral embedding materials:

Level 1: < 80 % RH
Level 2: limit curve between < 95 % RH at > 0 °C and < 80 % RH at ≥ 40 °C
Level 3: transient evaluation with WUFI® Corr

Evaluation Criteria – Summary

Impact of moisture content on thermal performance:

All building materials: U-values are normally related to the equilibrium moisture content of the materials at 80 % RH (critical in-situ moisture level). In case of higher moisture contents, especially in the heating period, a correction may be necessary. This can be done for example by the help of the postprocessor “Transient U value”.

Moisture resistant insulation materials: Moisture contents up to approx. 2 % by volume or 20 kg/m³ are normally unproblematic and already considered by the declared λ-value of the product. Higher moisture levels should be avoided or the influence on the λ-value should be considered adequately.

Natural fibre or moisture sensitive insulation materials need to remain below the resp. limit values to avoid degradation / decay of the materials. These limits are mostly below the ones relevant for an increase of the thermal conductivity and thus the decisive ones

Condensation inside the construction (on interfaces or in fibre insulations):

Without insulation:

smooth hydrophobic boundary layer material:	< 50 g/m²
fine structured hydrophobic or hydrophilic boundary layer material:	< 100 g/m²
coarse structured hydrophobic boundary layer material	< 150 g/m²

With fibre insulation in direct contact with the boundary, limits increase by at least 50 g/m².

Evaluation Criteria – Summary

Frost risk / interior insulated walls:

High moisture content at temperatures below 0 °C poses a risk of frost damage. In areas where such conditions occur, frost-resistant materials (exterior plasters, frost-resistant facing bricks, etc.) should normally be used.

WTA 6-5 [8] specifies that for non-frost-resistant materials that may be exposed to frost conditions after interior insulation has been installed, a moisture content of 30 % (related to the maximum water content) may only be exceeded if the air in the pores remains below 95 % RH. Under these conditions, even non-resistant materials will not suffer frost damage.

Wood or gypsum-containing materials should not be used or remain in areas, where the humidity levels in exceeds 95 % RH for long periods of time.

Moisture content in masonry:

The U-value is based on the thermal conductivity at 80 % relative humidity in the pore air of the materials. If this value is exceeded on average over a longer period of time, the thermal insulation properties would need to be corrected. However, high moisture content not only increases thermal conductivity but also results in additional heat losses through evaporative cooling. It also increases the risk of algae and fungal growth.

It is therefore a good idea to avoid long-term moisture contents above 90 % RH in the pores of the materials as far as possible, e.g., by improving the rainwater protection level.

Evaluation of typical constructions

Separate guidelines are available for the following types of construction, providing information on both the input data and the evaluation. This is usually illustrated with an example.

- **Exterior wall with interior insulation**
  → Handling of typical constructions in WUFI
- **Exterior wall with ETICS**
  → Handling of typical constructions in WUFI
  → Guideline for the calculation and evaluation of an ETICS with wood fibre insulation
- **Ventilated timber frame construction**
  → Handling of typical constructions in WUFI
- **Basement wall without ground water**
  → Handling of typical constructions in WUFI

Evaluation of typical constructions

- **Flat roof**
  → Guideline for the calculation of flat roofs

- **Green roof**
  → Guideline for the calculation of extensive green roofs

- **Gravel roof**
  → Guideline for the calculation of gravel roofs

- **Pitched roofs (ventilated)**
  → Guideline for the calculation of ventilated pitched roofs

Literature

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[2] WTA-Guideline 6-8: Assessment of humidity in timber constructions - Simplified verifications and simulation. August 2016.

[3] DIN 4108-2: Wärmeschutz und Energie-Einsparung in Gebäuden - Teil 2: Mindestanforderungen an den Wärmeschutz. Beuth Verlag, February 2013.

[4] DIN 68800-2: Holzschutz - Teil 2: Vorbeugende bauliche Maßnahmen im Hochbau. Beuth Verlag, February 2022.

[5] EN 1995-1-1: Design of timber structures - Part 1-1: General - Common rules and rules for buildings. Beuth Verlag, December 2010.

[6] Zirkelbach, D., Tieben, J., Tanaka, E., Pfabigan N., Andresen, N., Bachinger, J., Nusser, B.: Bauteile mit Dämmmaterial aus nachwachsenden Rohstoffen: Fokus (Hygro-)Thermik (ThermNat). Projektbericht, IGF-Forschungsvorhaben CORNET 271 EN (2023).

[7] Tanaka, E., Schwerd, R., Pfabigan, N., Tieben, J., Bachinger, J., Zirkelbach, D.: Hygrothermal limit curves and transient decay prediction for natural fibre insulation. 2nd International Conference on Moisture in Buildings. London, 2023. doi.org/10.14293/ICMB230038.

[8] WTA-Guideline 6-5: Innendämmung nach WTA II – Nachweis von Innendämmsystemen mittels numerischer Berechnungsverfahren. April 2014.

[9] Bludau, Ch., Künzel, H., Marra, E., Tanaka, E., Zirkelbach, D., Hirsch, H., Heyn, R., Grunewald, J., Petzold, H.: Erarbeitung wissenschaftlich begründeter Bewertungskriterien und Implementierung eines Nachweisverfahrens für die schadenfreie energetische Bestandssanierung und Neubauplanung (NaVe). Forschungsbericht EnOB: Energieoptimierte Gebäude und Quartiere - dezentrale und solare Energieversorgung Auftrag des Bundesministeriums für Wirtschaft und Energie (BMWi), Förderkennzeichen:03ET1649 A/B, 2023