Criteria and algorithms

Certified Passive house Component – Balcony connection

Version 2.1, 01.11.2024, am

Note: Certificates are currently only being issued for the ‘arctic’, ‘cold’, ‘cool, temperate’, ‘warm, temperate’ and ‘warm’ climate region.

Legal notes: For all construction details, only the heat flow is examined. The absence of condensation or the internal moisture transport processes and the protection against moisture ingress as well as other aspects of building physics, construction practice or statics are not the subject of the examination. This is the responsibility of the applicant, designer or manufacturer, if required. The PHI assumes that the submitted documents are free of third party rights. By submitting the documents for testing, the applicant declares that he/she owns the rights to these in full

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1 Preface

Passive House buildings offer optimal thermal comfort with minimal energy expenditure, making them economically advantageous when considering life-cycle costs. To achieve this level of comfort and low cost efficiency, the thermal quality of components used in Passive Houses must meet stringent requirements. These requirements are directly derived from the Passive House criteria for hygiene, temperature, and efficiency, as well as from feasibility studies. The Passive House Institute has established component certification in order to define quality standards, facilitate the availability of highly efficient products, promote their expansion, and provide planners and building owners with reliable data for energy balancing tools. In order to define a reliable quality, the Passive House Institute grants the quality seal "Certified Passive House Component – Balcony connection“.

2 Procedure

The thermal bridge coefficient is evaluated using FEM heat flow simulations. A predefined wall construction, based on the relevant climate zone, is used for this evaluation. The insulation thickness, and thus the heat transfer coefficient of the uninterrupted assembly, varies according to the climate zone.

The appropriate climate zone is determined based on the applicant's main location[1]. An overview of the different climate zones is provided in the following graphic.

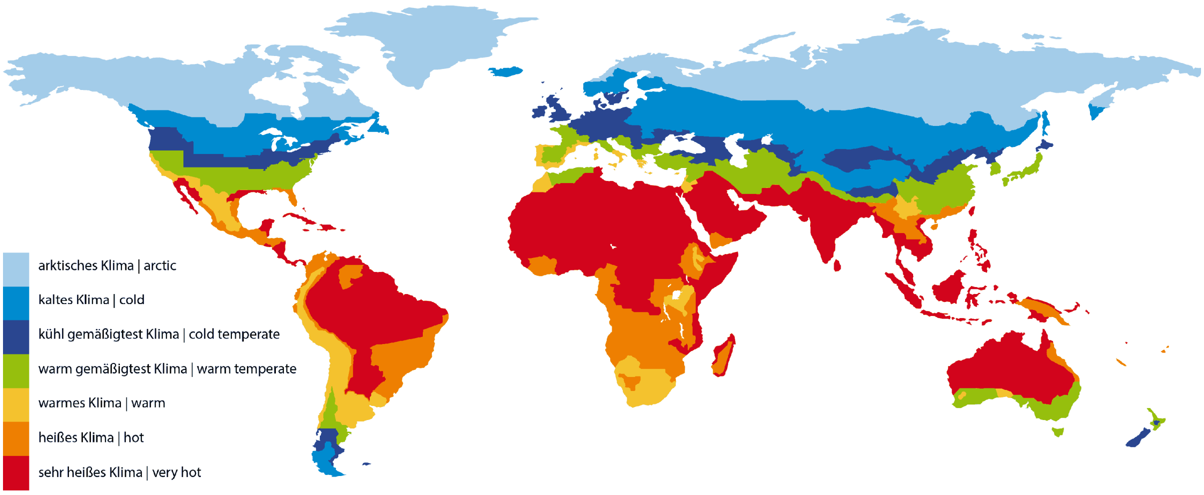


Figure 1: Climate zones

Table 1: Reference wall assembly

layer	d [mm]	**λ** [W/(m.K)]
interior plaster	15	0.51
reinforced concrete	200	2.3
thermal insulation	varies	0.035
exterior plaster	10	0.7

[1] Based on the closest PHPP climate dataset

Insulation thicknesses are adjusted as specified in Table 2, which lists the insulation thicknesses, corresponding heat transfer coefficients, and temperature factor requirements for each climate zone.

Table 2: Reference heat transfer coefficients / insulation thicknesses, temperature factors for each climate zone

Climate zone	U-value reference façade [W/(m².K)]	Insulation thickness [mm]	Hygiene criterion Minimum temperature factor $f_{Rsi = 0.25\,m^2.K/W}$ [-]	Temperature criterion (purely opaque constructions) Minimum temperature factor $f_{Rsi = 0.25\,m^2.K/W}$ [-]
arctic climate	0.09	380	0.8	0.9
cold climate	0.12	280	0.75	0.88
cool, temperate climate	0.13	250	0.7	0.86
warm, temperate climate	0.23	140	0.65	0.82
warm climate	0.48	60	0.55	0.74

Balcony connection elements are modelled to reflect real conditions and then inserted into the assembly. A distinction is made between:

1. Connection elements that can bear negative moments (cantilevered balconies)
2. Connection elements that can only bear shear forces (supported balconies)

Manufacturers have the option to determine thermal bridge heat loss coefficients either through three-dimensional FEM heat flow simulations or by using two-dimensional FEM heat flow simulations with replacement models that have equivalent heat transfer resistance.

If thermal bridge heat loss coefficients are calculated with replacement models, the equivalent thermal conductivity values must be provided by the manufacturer. These values are then validated through comparison simulations.

If thermal bridge heat loss coefficients are determined via 3D simulations, the equivalent thermal conductivities for the replacement model are derived from these heat flow simulations.

For linear balcony connection elements, the equivalent thermal conductivity of the replacement is determined according to Section 2.3.

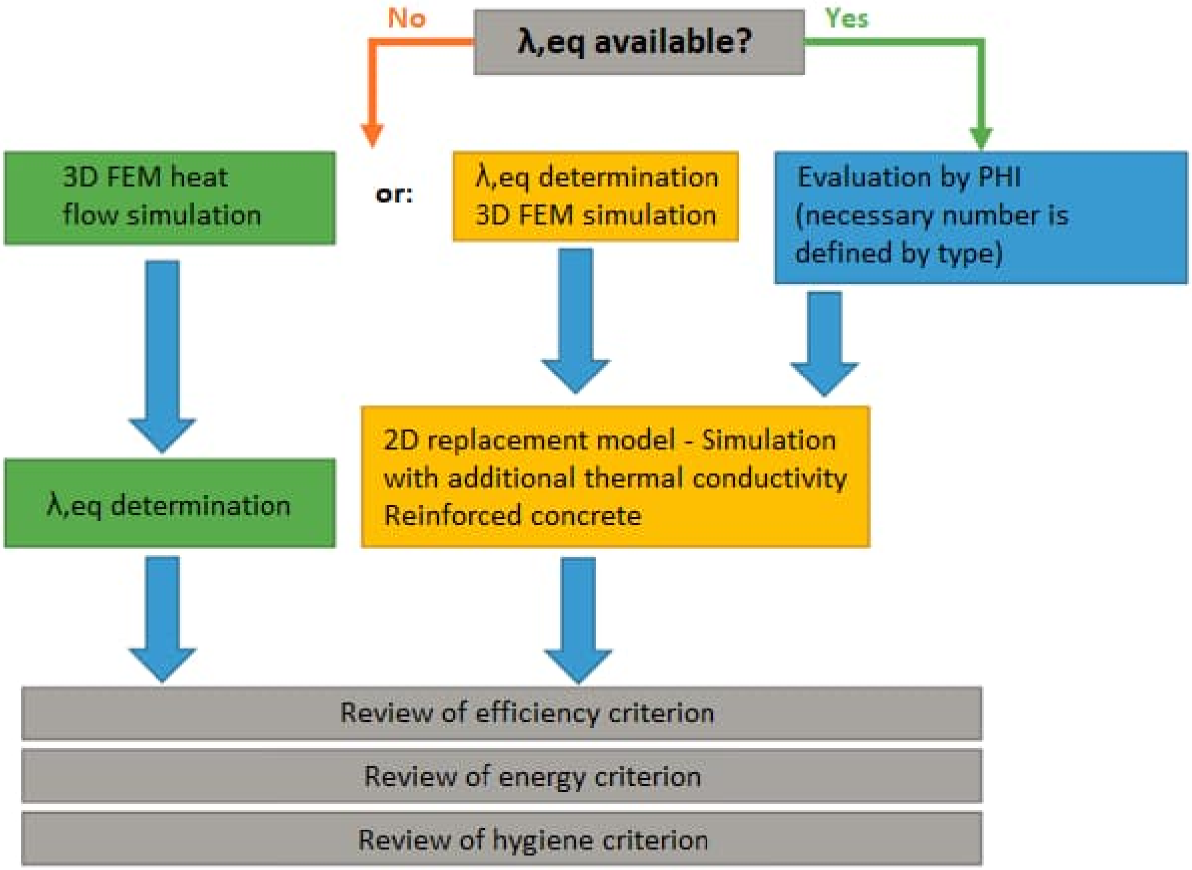


Figure 1: Certification flow chart

2.1 3D heat flow simulation

For this purpose, the manufacturer provides accurate three-dimensional models that are integrated into the wall construction. The linear heat transfer coefficient is then determined. In case of point penetrations, the point-specific heat transfer coefficient is calculated and then converted into a linear coefficient depending on the distance between points.

For linear connection elements, the following applies:

$$\psi = \frac{\Phi 3D - \Phi 1D}{\Delta T * l}$$

For point connection elements, the following applies:

$$\psi = \frac{\chi * l}{a} = \frac{\Phi 3D - \Phi 1D}{\Delta T * l}$$

where:

Ψ = linear thermal bridge loss coefficient [W/(m.K)]
Φ_{1D} = Heat flow of the undisturbed structure [W] (see Table 2)
Φ_{3D} = Heat flow of the structure [W]
Δ_T = Temperature difference [K]
X = point thermal bridge loss coefficient [W/K]
l = Balcony width (corresponds to the depth of the calculation model) [m]
a = Distance between point connection elements [m]

2.2 2D replacement method

In the heat flow simulation using replacement models, balcony connection elements are represented as two-dimensional (rectangular) substitute bodies with thermal properties that match those of the real component. The heat transfer resistance of the substitute geometry with the thermal conductivity λ_{eq}, corresponds to the heat transfer resistance of the 3D original model. The procedure for determining the equivalent thermal conductivity can be found in Section **Fehler! Verweisquelle konnte nicht gefunden werden.**. The models are created analogously to the 3D models. Consideration of the reinforcement in the reinforced concrete is achieved by increasing the thermal conductivity of the concrete, λc[2], in the connection area (balcony and ceiling) of the connection element. The reinforcement proportion varies with the balcony height as follows:

1. Balconies with a height of h ≤ 200 mm: + $\Delta\lambda_C$ = +0.7 W/(m.K)
2. Balconies with a height of h > 200 mm: + $\Delta\lambda_C$ = +0.3 W/(m.K)

[2] λc = 2.3 W/(m.K) without surcharge

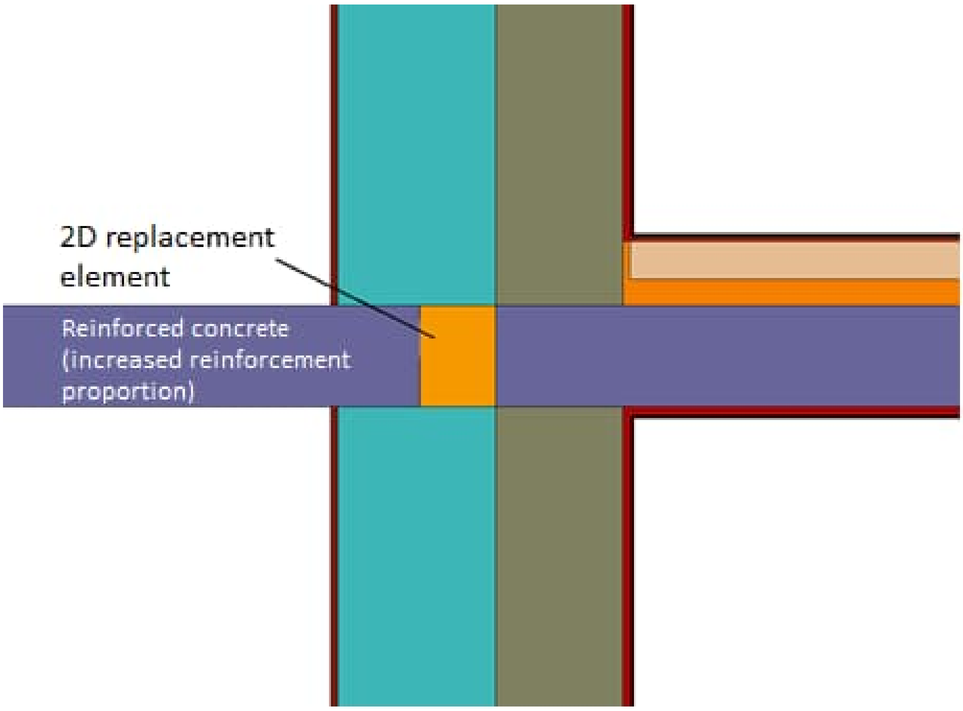


Figure 2: 2D replacement model – taking the reinforcing bars into account by increasing the thermal conductivity of the reinforced concrete in the area of the connection element

The following applies to linear connection elements:

$$\psi = \frac{\Phi 2D - \Phi 1D}{\Delta T * l}$$

where:

Ψ = linear thermal bridge loss coefficient [W/(m.K)]
Φ_{1D} = Heat flow of the undisturbed structure [W] (see Table 2)
Φ_{2D} = Heat flow of the structure [W]
Δ_T = Temperature difference [K]
l = Balcony width [m]

For point fastenings, an initial three-dimensional heat flow simulation is required to determine an equivalent substitute thermal conductivity λ_{eq} for a specified spacing of the elements. Values for distances between the determined points can be interpolated.

2.3 Determination of the characteristic values of the replacement geometry according to EAD[3]

The Passive House Institute offers the determination of equivalent thermal conductivities λ_{eq} in accordance with (EAD 050001-00-0301, Februar 2018). The procedure and the simulation and calculation boundary conditions can be found in the section below. For this purpose, the client provides realistic, three-dimensional balcony connection models. The Passive House Institute determines the characteristic values of these

[3] European Assessment Document

models using simulation models according to the EOTA[4] boundary conditions through FEM heat flow simulation. The rectangular geometry required for determining thermal bridge loss coefficients with replacement models with equivalent thermal conductivity according to EAD, is derived from the real geometry of the linear balcony connection profile. This geometry corresponds to an idealised rectangle. The replacement model has a heat transfer resistance equivalent to that of the original model. Based on the geometric characteristics, an equivalent thermal conductivity can be determined, allowing for two-dimensional heat flow and thermal bridge calculations. The determination of values according to EAD uses a calculation model independent of the construction. In national building approval, a typical wall construction with an external thermal insulation composite system (ETICS) is specified as the calculation model. By determining the values according to EAD and using the construction-independent calculation model, product values that are independent of the installation condition are established.

The thermal bridge loss coefficients from the two-dimensional heat flow simulation with replacement models according to EAD are qualitatively compared and evaluated with values from the 3D reference simulation.

The heat transfer resistance is determined according to the boundary conditions of (DIN EN ISO 6946:2018, 2018) and (DIN EN ISO 10211:2018, 2018). The equivalent heat transfer resistance R_{eq} is determined using numerical solutions (Finite Element Method) and a detailed 3D model of the thermal separation element. The nominal thickness $d_{n,TI}$ is determined, considering indentations and depressions, and any bulges. The thermal conductivities of the components are rated values taken from (DIN EN ISO 10456:2010-05 , 2010). The thermal conductivity of stainless steel is specified according to (DIN EN 10088-1). The characteristic values for the thermal conductivity of the insulation are specified according to (DIN EN 13162) and (DIN EN 13163), with rated values determined according to (DIN EN ISO 10456:2010-05 , 2010).

According to these specifications, the equivalent thermal conductivities of the replacement model λ_{eq} and the equivalent heat transfer resistance R_{eq} are determined. The following applies:

$$\lambda_{eq,\,EAD} = \frac{\left[\frac{Q_{3D}}{\Delta T * h}\right]^{-1} - R_{se} - R_{si} - R_{con}}{d}$$

where:

Q_{3D}	= Heat flow from three-dimensional simulation	
ΔT	= Temperature difference	= 20 K
R_{se}	= Heat transfer resistance outside	= 10^{-6} m².K/W
R_{si}	= Heat transfer resistance inside	= 10^{-6} m².K/W

[4] European Organisation for Technical Assessment

R_{con} = Thermal resistance concrete = 0.06 m/(2.3 W/(m.K)) = 0.026087 m².K/W
h = Height of the component [m]
d = Depth of the component [m]

2.4 Optional additional installation situations

Optionally, additional thermal bridge loss coefficients can be determined upon request for other connection situations, such as a balcony exit. These values are provided for informational purposes only and are not part of the certification.

3 Efficiency criterion

As a key criterion, heat losses are evaluated based on the possible load-bearing capacity (primary load-bearing stage). The design resistances must be submitted by the manufacturer and, upon request, with the respective national approval.

For balcony connection elements that can absorb negative moments, the following applies:

$$Eff.t. = \frac{\psi}{M,\mathrm{Rd}} * -1000 < 10\, W/(kNmK)$$

For balcony connection elements that can only absorb transverse forces, the following applies:

$$Eff.s.f. = \frac{\psi}{\mathrm{V,Rd}} * 1000 < 3\, W/(kNK)$$

where:

Ψ = linear thermal bridge loss coefficient [W/(m.K)]
$V_{,Rd}$ = Design resistance shear force [kN/m]
$M_{,Rd}$ = Rated resistance torque [kNm/m]
Eff.t. = Efficiency class (turning moment, torque) [W/(kNm.K)]
Eff.s.f. = Efficiency class (shear force, lateral force) [W/(kN.K)]

4 Efficiency class

Table 3: Efficiency class designation

Efficiency class	Designation	Requirement for supported balconies	Requirement for cantilevered balconies
cool, temperate climate phC CERTIFIED COMPONENT Passive House Institute	certifiable component	< 3.0 W/(kNm.K)	< 10.0 W/(kN.K)
cool, temperate climate phB CERTIFIED COMPONENT Passive House Institute	basic component	< 2.5 W/(kNm.K)	< 6.0 W/(kN.K)
cool, temperate climate phA CERTIFIED COMPONENT Passive House Institute	advanced component	< 1.5 W/(kNm.K)	< 3.0 W/(kN.K)
cool, temperate climate phA+ CERTIFIED COMPONENT Passive House Institute	very advanced component	< 1.0 W/(kNm.K)	< 2.0 W/(kN.K)

According to the determined values, the components are classified into efficiency classes. Table 3 lists the required values for each class.

5 Energy criterion

For the correct energy balance of a specific building, identifying and quantifying thermal bridges is crucial. Therefore, the Passive House Institute includes the thermal bridge loss coefficients of certified components as a significant part of the evaluation in the certificates. In addition to meeting efficiency requirements, absolute heat losses are also limited.
For balcony connection elements that can absorb negative moments, the following applies:

$$\Psi_{border} \leq 0.25 \text{ W/(m.K)}$$

For balcony connection elements that can only absorb transverse forces, the following applies:

$$\Psi_{border} \leq 0.20 \text{ W/(m.K)}$$

6 Hygiene and temperature criteria

Thermal bridges are weak points in the building envelope. These weak points lead to increased heat flow and consequently a lower temperature on the interior surface of the affected component. If surface temperatures are too low, it can negatively impact comfort and increase relative humidity, which raises the risk of mould growth and structural damage. When the specified minimum temperature factor is achieved, mould and condensation can be reliably avoided under typical outdoor temperatures, indoor temperatures, and humidity levels. The colder the external climate, the higher the requirements for the temperature factor.

To prevent these effects, the minimum occurring temperature factor f_{Rsi} is determined based on the climate zone, with a defined internal heat transfer resistance of R_{si} = 0.25 m².K/W, as outlined in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

6.1 Calculation of f_{Rsi}

Calculation of the temperature factor $f_{Rsi} = \frac{\theta_{si} - \theta_a}{\Theta_i - \Theta_a}$

where:

θ_{si} = Minimum internal surface temperature from multidimensional heat flow calculation [°C]

θ_a = Outside temperature from multidimensional heat flow calculation [°C]

θ_i = Indoor temperature from multidimensional heat flow calculation [°C]

For purely opaque details, a requirement value is also defined to meet temperature criteria. The boundary conditions for determining the key values can be found in the following table.

Table 4: Boundary conditions requirement values

Region No.	Name	Boundary condition for hygiene criterion		Hygiene criterion		Dewpoint criterion		Ambient temperature for comfort criterion [°C]	Maximum heat transmission coefficient			
		θ_a	rHi	$\theta_{si,min}$	f_{Rsi} =0,25m²K/W	$\theta_{si,min}$	f_{Rsi} =0,25m²K/W		Orientation	[°]	$U_{W,inst.}$	U_W
1	Arctic	-34,00	0,40	9,20	0,80	6,00	0,74	-50	vertical inclined horizontal	90 45 0	0,45 0,50 0,60	0,40 0,50 0,60
2	Cold	-16,00	0,45	11,00	0,75	7,80	0,66	-28	vertical inclined horizontal	90 45 0	0,65 0,70 0,80	0,60 0,70 0,80
3	Cool-temperate	-5	0,50	13	0,70	9	0,57	-16	vertical inclined horizontal	90 45 0	0,85 1,00 1,10	0,80 1,00 1,10
4	Warm-temperate	3,00	0,55	14,00	0,65	10,70	0,45	-9	vertical inclined horizontal	90 45 0	1,05 1,10 1,20	1,00 1,10 1,20
5	Warm	10,00	0,70	15,50	0,55	14,30	0,43	-4	vertical inclined horizontal	90 45 0	1,25 1,30 1,40	1,20 1,30 1,40
6	Hot	not relevant		not defined		not relevant		not relevant			1,25	1,20
7	very hot, often humid	not relevant		not defined		not relevant		not relevant			1,05	1,00

7 Boundary conditions and determination of characteristics values

7.1 Temperature boundary conditions and heat transfer resistances

Outside temperature: -10 °C
Interior temperature: 20 °C
Heat transfer resistance outside: 0.04 m².K/W
Heat transfer resistance inside: 0.13 m².K/W
Heat transfer resistance inside (f_{Rsi}): 0.25 m².K/W

7.2 Material properties

In principle, the rated value of the thermal conductivity is used in the calculation of the U-values and the heat flow simulations. This applies as long as no other regulations of the Passive House Institute are published.

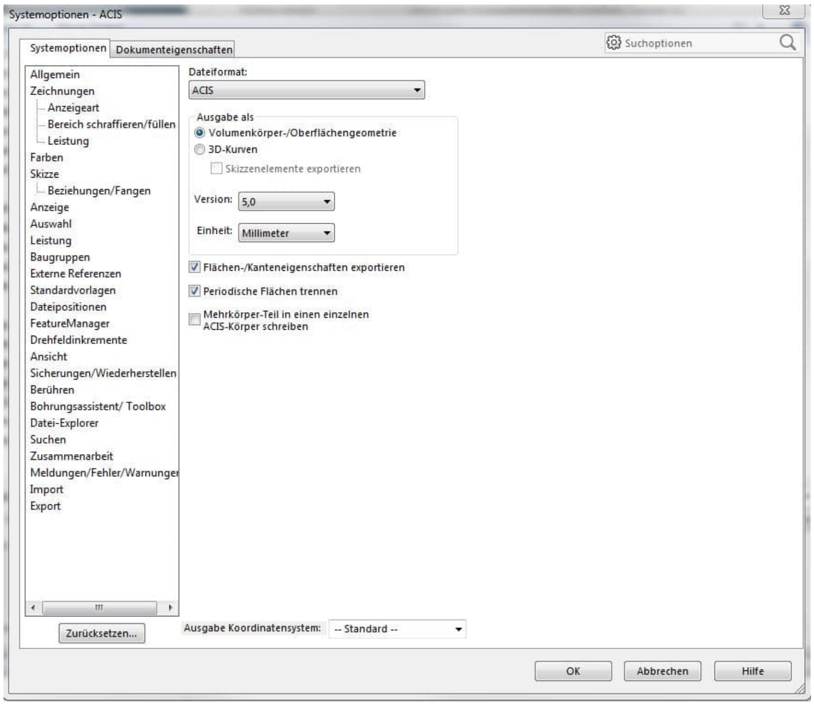
If no rated value is available, a nominal value of thermal conductivity determined by a recognized materials testing institute according to relevant standards can be used as a basis. In line with the design value adjustments, this nominal value is usually multiplied by 1.25, and the result is used in the calculation.

The thermal conductivity is the nominal value determined from the measured data (from measurements on at least three different samples from different batches representative of the usual product variations, taking aging into account). For this purpose, a statistical evaluation, as described in ISO 10456:2007 Annex C, with a 90 % fractile is applied.

8 Documents required

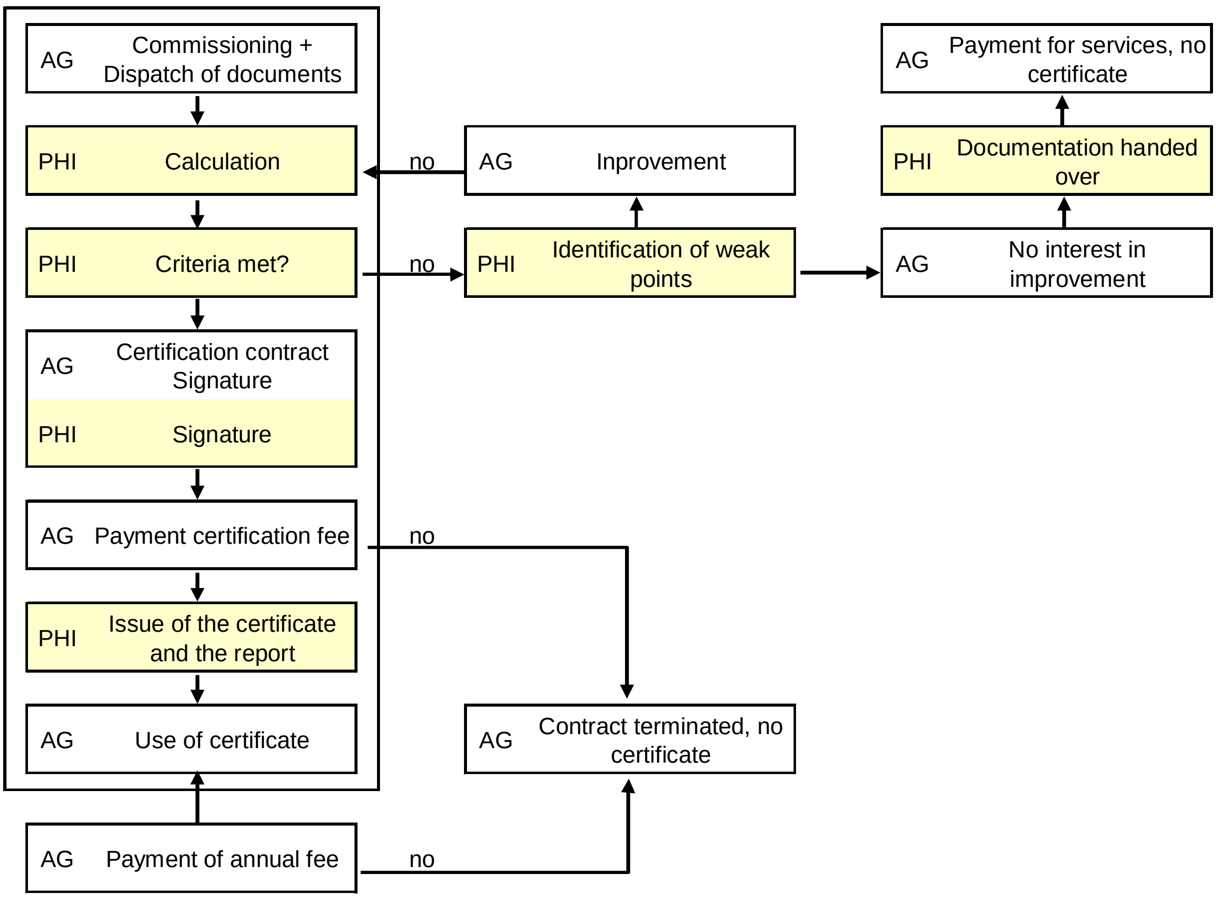
The following documents, along with additional materials upon request, must be provided by the applicant to the PHI for calculation:

1. Detailed drawings of balcony connection elements: these must be submitted as DXF or DWG files. Materials with different thermal conductivities should be marked with distinct representations. Tables containing rated values of thermal conductivity, layer thicknesses, and material descriptions for all component structures must be provided. All materials, even those outside the standard component structures, should be listed and specified.
2. Complete general construction approval or equivalent documents: this includes design resistance values.
3. 3D models in ACIS format (.sat) or DWG drawing files with closed solid bodies: for export, please use the following or similar settings:



4. Verifiable documentation on structural analysis and load-bearing capacity.

8.1 Certification procedure



9 Bibliography

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