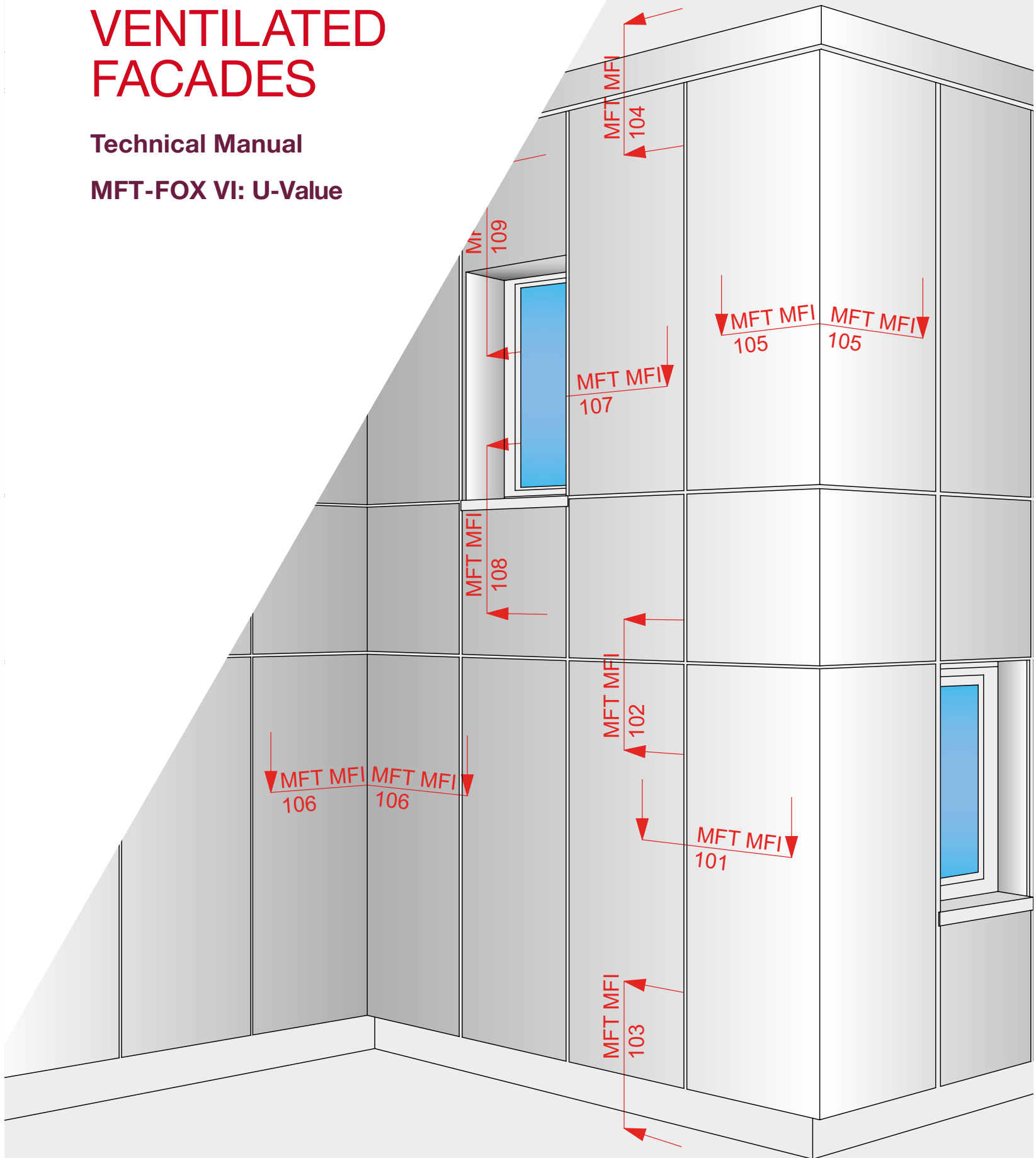




VENTILATED FACADES

Technical Manual

MFT-FOX VI: U-Value

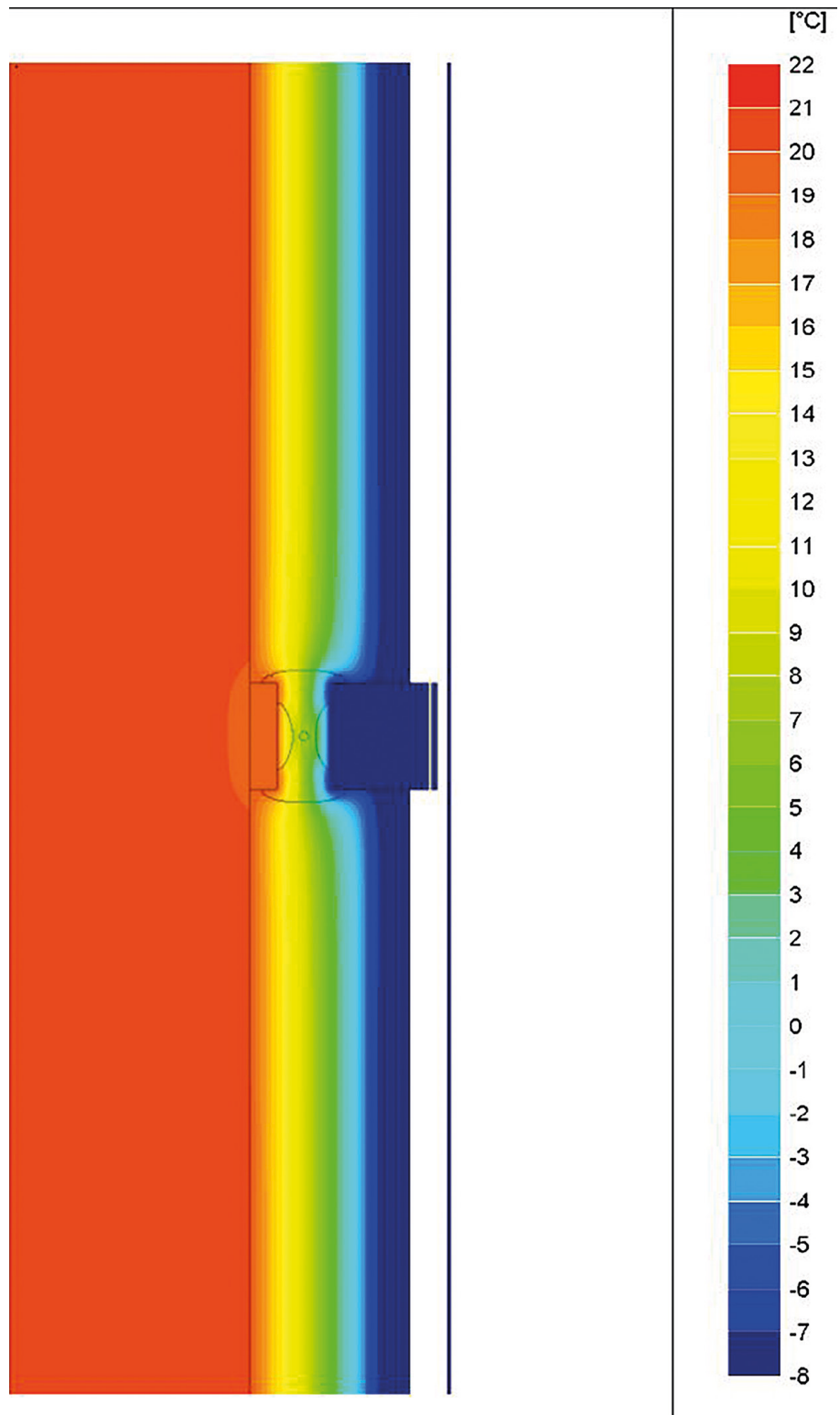


DESCRIPTION

The U-factor or U-value is the overall heat transfer coefficient that describes how well a building element conducts heat or the rate of heat transfer (in watts) through one square metre of a structure divided by the difference in temperature across the structure.

The elements are commonly assemblies of many layers of components such as those that make up walls/floors/roofs etc. These values measure the rate of heat transfer through a building element over a given area under standardised conditions. The usual standard is at a temperature gradient of 24° C (75° F) at 50% humidity with no wind. It is expressed in watts per meter squared kelvin (W/m²K).

A lower U-factor/value indicates a greater reduction of heat transfer.



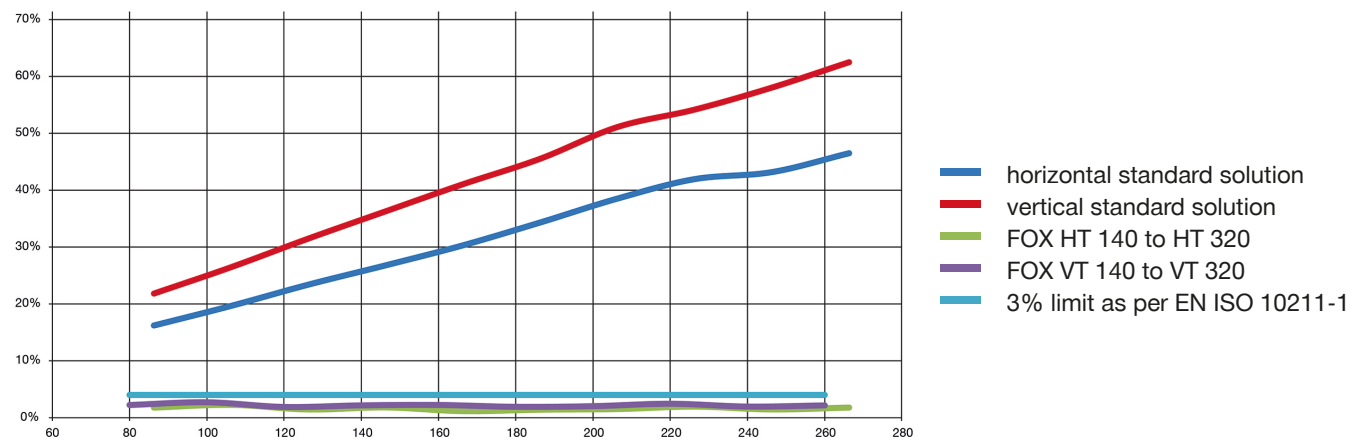
IMPACT DUE TO THE SUBSTRUCTURE

Today’s targets, requirements and standards relating to the efficiency and sustainability of buildings inevitably demand new, innovative solutions, also for facades.

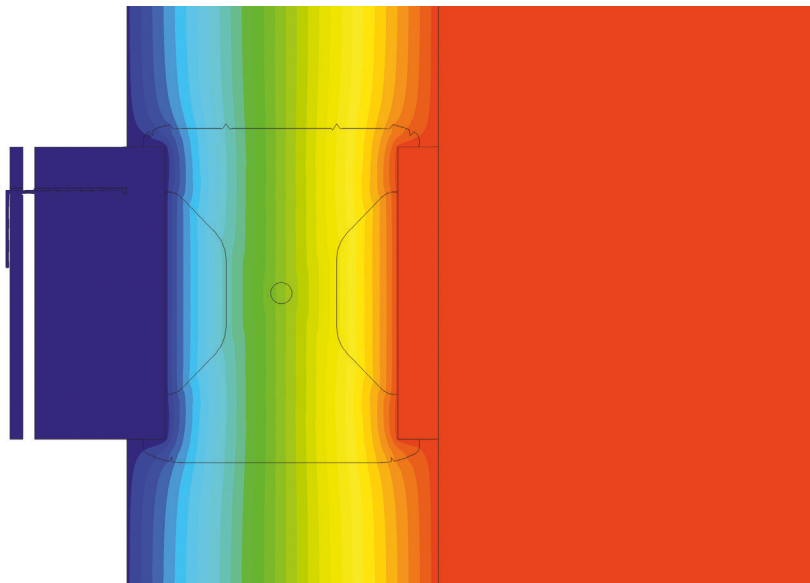
Various studies, including tests carried out by the Swiss Federal Laboratories for Materials Science and Technology (EMPA – Eidgenössische Materialprüfanstalt) have shown, for example, that the requirements of the “Passivhaus” standards can no longer be met by facade substructures constructed only from aluminum.

Through use of brackets such as the Hilti MFT-FOX VT/HT, designed to eliminate thermal bridging, not only can the thickness of the insulating layer be reduced, but an up to 40% better U-value can be achieved compared to metal structures.

The diagram compares standard aluminum substructures to substructures designed to reduce thermal bridging.



The isothermal image clearly shows the uniform heat distribution. The result is a facade with virtually no losses due to thermal bridging.



CALCULATION METHOD

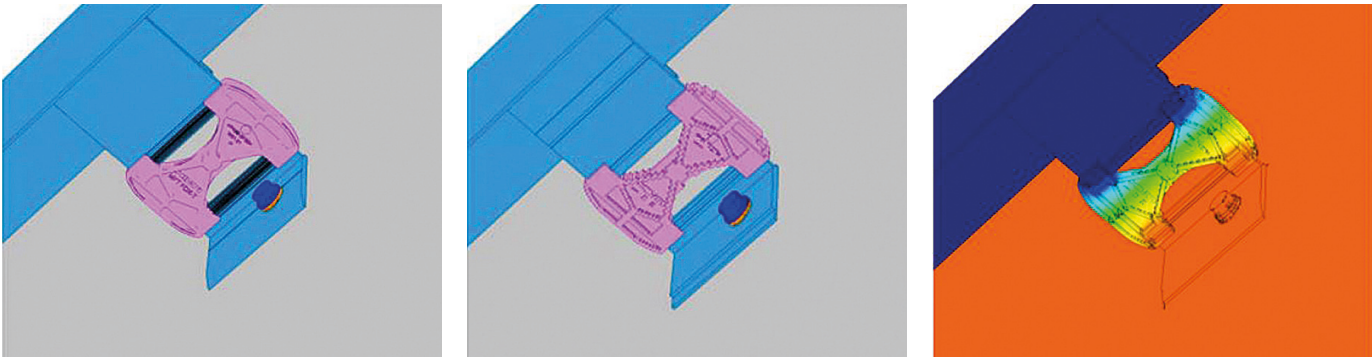
The numerical calculations were performed in accordance with EN ISO 10211.

Simplified models

The test object is a wall (made of concrete, sand-lime block or standard brickwork in two thicknesses) on which a framework for supporting a ventilated facade is mounted using anchor bolts. The following simplifications were made in order to model the inputs for the calculation program:

The bolt is shown as a solid cylinder; the frame anchor is shown as a hollow cylinder.

The modeling method and the definition of grid points conform to the requirements of the EN ISO 10211-1 standard. A detailed listing of the input data for the calculated cases is given in the appendix.



Calculations

Thermal conduction was evaluated for a one square meter section of the wall clad with various thicknesses of insulation. A single bracket was mounted in the center of the test wall area, anchored to the base material.

CALCULATION METHOD

Standard for thermal bridge calculation as per EN ISO 10211-1

Thermal bridges present in the facade were taken into account as follows:

$$U = \frac{U_0 \cdot A + \sum \Psi \cdot l + \sum \chi}{A} = U_0 + \Delta U$$

with:

- Area-dependent additional term for the total thermal bridge:

$$\Delta U = \frac{L^{3D}}{A} - U_0$$

- Linear thermal transmittance:

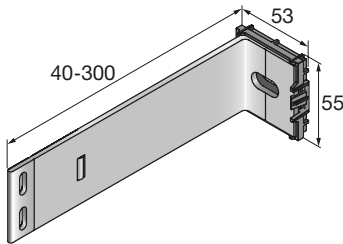
$$\Psi = L^{2D} - U_0 \cdot l$$

- Point thermal transmittance:

$$\chi = L^{3D} - \Psi \cdot l - U_0 \cdot A$$

$$U_0 = \frac{1}{\left(\frac{1}{h_i} + \frac{d_v}{\lambda_w} + \frac{d_D}{\lambda_D} + \frac{1}{h_e}\right)} = \frac{1}{\left(\frac{1}{h_i} + R_v + R_D + \frac{1}{h_e}\right)}$$

U_0	Heat transmittance of the unmodified wall in W/(m ² K)
ΔU	Additional term due to thermal bridges in W/(m ² K)
A	Wall area in m ²
l	Length of the linear thermal bridge in m
L^{2D}	Thermal coupling coefficient for a 2D-calculation in W/(m ² K)
L^{3D}	Thermal coupling coefficient for a 3D-calculation in W/K
h_i	Heat transfer coefficient on warm side in W/(m ² K)
h_e	Heat transfer coefficient on cold side in W/(m ² K)
d_v	Thickness of underlying wall structure in m
d_D	Thickness of insulation layer in m
λ_w	Thermal conductivity of underlying wall structure in W/(m ² K)
λ_D	Thermal conductivity of insulation layer in W/(m ² K)
R_v	Thermal resistance of underlying wall structure in (m ² K)/W
R_D	Thermal resistance of insulation layer in (m ² K)/W



MFT-FOX VI S – CONCRETE 180 MM

Technical data:

Bracket

Material	EN-AW-6063 T66
Yield strength	200 N/mm ²
Modulus of elasticity	70.000 N/mm ²
Isolator material	Polypropylene
Thermal conductivity polypropylene	0.117 W/mK
Thermal conductivity aluminum	160 W/mK

Substrate

Material	Concrete
Thickness d_v	180 mm
Thermal conductivity λ_w	1.8 W/mK
Thermal resistance R_v	0.1 W/mK

Insulation

Material	Mineral wool
Thickness d_D	50-300 mm
Thermal conductivity λ_D	0.035 W/mK

MFT- FOX VI Small Brackets			FOX-VI 80 S	FOX-VI 100 S	FOX-VI 120 S	FOX-VI 140 S	FOX-VI 160 S	FOX-VI 180 S	FOX-VI 200 S	FOX-VI 220 S	FOX-VI 240 S	FOX-VI 260 S	FOX-VI 280 S	FOX-VI 300 S
Insulation thickness	d_D	[mm]	50	70	100	120	140	160	180	200	220	240	250	300
Thermal transmission coefficient of the undisturbed wall	U_0	[W/m ² K]	0.5591	0.4237	0.3108	0.2640	0.2294	0.2028	0.1817	0.1646	0.1505	0.1386	0.1333	0.1120
Punctual thermal bridge loss coefficient of the bracket	χ	[W/K]	0.0113	0.0145	0.0338	0.0339	0.0338*	0.0337	0.0336*	0.0328	0.0324*	0.032*	0.0318	0.0303

*value interpolated

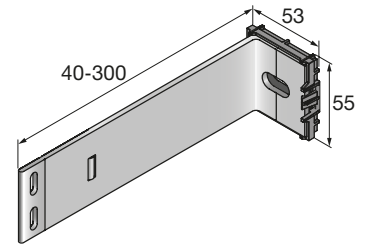
U-Value**

(surface A=1.0 m², profile length 1.0 m, profile 30 mm air side)

Number of brackets	1	0.5875	0.4553	0.3446	0.2979	0.2632	0.2365	0.2153	0.1974	0.1829	0.1706	0.1651	0.1423
Number of brackets	2	0.6159	0.4869	0.3784	0.3318	0.2970	0.2702	0.2489	0.2302	0.2153	0.2026	0.1969	0.1726
Number of brackets	3	0.6443	0.5185	0.4122	0.3657	0.3308	0.3039	0.2825	0.2630	0.2477	0.2346	0.2287	0.2029
Number of brackets	4	0.6727	0.5501	0.4460	0.3996	0.3646	0.3376	0.3161	0.2958	0.2801	0.2666	0.2605	0.2332
Number of brackets	5	0.7011	0.5817	0.4798	0.4335	0.3984	0.3713	0.3497	0.3286	0.3125	0.2986	0.2923	0.2635

**MFT-FOX V S and profile T 120 x 60 x 1.8 30 inside the insulation

MFT-FOX VI S – THICK STANDARD BRICK 300 MM



Technical data:

Bracket

Material	EN-AW-6063 T66
Yield strength	200 N/mm ²
Modulus of elasticity	70.000 N/mm ²
Isolator material	Polypropylene
Thermal conductivity polypropylene	0.117 W/mK
Thermal conductivity aluminum	160 W/mK

Substrate

Material	Thick standard brick
Thickness d_v	300 mm
Thermal conductivity λ_w	0.44 W/mK
Thermal resistance R_v	0.682 W/mK

Insulation

Material	Mineral wool
Thickness d_D	50-300 mm
Thermal conductivity λ_D	0.035 W/mK

MFT- FOX VI Small Brackets			FOX-VI 80 S	FOX-VI 100 S	FOX-VI 120 S	FOX-VI 140 S	FOX-VI 160 S	FOX-VI 180 S	FOX-VI 200 S	FOX-VI 220 S	FOX-VI 240 S	FOX-VI 260 S	FOX-VI 280 S	FOX-VI 300 S
Insulation thickness	d_D	[mm]	50	70	100	120	140	160	180	200	220	240	250	300
Thermal transmission coefficient of the undisturbed wall	U_0	[W/m ² K]	0.4218	0.3399	0.2632	0.2288	0.2023	0.1814	0.1643	0.1502	0.1384	0.1282	0.1237	0.1051
Punctual thermal bridge loss coefficient of the bracket	χ	[W/K]	0.0113	0.0145	0.0179	0.0178	0.0191*	0.0203	0.0207*	0.0211	0.0213*	0.0215*	0.0216	0.0215

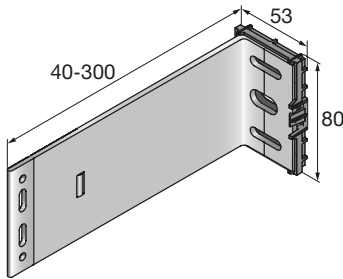
*value interpolated

U-Value**

(surface A=1.0 m², profile length 1.0 m, profile 30 mm air side)

Number of brackets	1	0.4331	0.3544	0.2811	0.2477	0.2214	0.2017	0.1850	0.1713	0.1597	0.1497	0.1453	0.1266
Number of brackets	2	0.4444	0.3689	0.2990	0.2666	0.2405	0.2220	0.2057	0.1924	0.1810	0.1712	0.1669	0.1481
Number of brackets	3	0.4557	0.3834	0.3169	0.2855	0.2596	0.2423	0.2264	0.2135	0.2023	0.1927	0.1885	0.1696
Number of brackets	4	0.4670	0.3979	0.3348	0.3044	0.2787	0.2626	0.2471	0.2346	0.2236	0.2142	0.2101	0.1911
Number of brackets	5	0.4783	0.4124	0.3527	0.3233	0.2978	0.2829	0.2678	0.2557	0.2449	0.2357	0.2317	0.2126

**MFT-FOX V S and profile T 120 x 60 x 1.8 30 inside the insulation



MFT-FOX VI M – CONCRETE 180 MM

Technical data:

Bracket

Material	EN-AW-6063 T66
Yield strength	200 N/mm ²
Modulus of elasticity	70.000 N/mm ²
Isolator material	Polypropylene
Thermal conductivity polypropylene	0.117 W/mK
Thermal conductivity aluminum	160 W/mK

Substrate

Material	Concrete
Thickness d_v	180 mm
Thermal conductivity λ_w	1.8 W/mK
Thermal resistance R_v	0.1 W/mK

Insulation

Material	Mineral wool
Thickness d_D	50-300 mm
Thermal conductivity λ_D	0.035 W/mK

MFT- FOX VI Medium Brackets			FOX-VI 80 M	FOX-VI 100 M	FOX-VI 120 M	FOX-VI 140 M	FOX-VI 160 M	FOX-VI 180 M	FOX-VI 200 M	FOX-VI 220 M	FOX-VI 240 M	FOX-VI 260 M	FOX-VI 280 M	FOX-VI 300 M
Insulation thickness	d_D	[mm]	50	70	100	120	140	160	180	200	220	240	250	300
Thermal transmission coefficient of the undisturbed wall	U_0	[W/m ² K]	0.5591	0.4237	0.3108	0.2640	0.2294	0.2028	0.1817	0.1646	0.1505	0.1386	0.1333	0.1120
Punctual thermal bridge loss coefficient of the bracket	χ	[W/K]	0.0367	0.041	0.0439	0.0443	0.0443*	0.0442	0.0439*	0.0436	0.0431*	0.0426*	0.0424	0.0406

*value interpolated

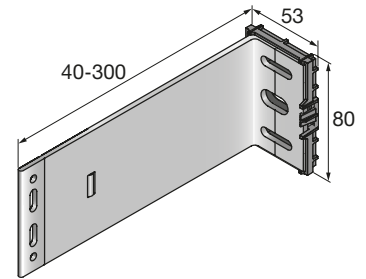
U-Value**

(surface A=1.0 m², profile length 1.0 m, profile 30 mm air side)

Number of brackets	1	0.5958	0.4647	0.3547	0.3083	0.2737	0.2470	0.2256	0.2082	0.1936	0.1812	0.1757	0.1526
Number of brackets	2	0.6325	0.5057	0.3986	0.3526	0.3180	0.2912	0.2695	0.2518	0.2367	0.2238	0.2181	0.1932
Number of brackets	3	0.6692	0.5467	0.4425	0.3969	0.3623	0.3354	0.3134	0.2954	0.2798	0.2664	0.2605	0.2338
Number of brackets	4	0.7059	0.5877	0.4864	0.4412	0.4066	0.3796	0.3573	0.3390	0.3229	0.3090	0.3029	0.2744
Number of brackets	5	0.7426	0.6287	0.5303	0.4855	0.4509	0.4238	0.4012	0.3826	0.3660	0.3516	0.3453	0.3150

**MFT-FOX V M and profile T 120 x 60 x 1.8 30 inside the insulation

MFT-FOX VI M – THICK STANDARD BRICK 300 MM



Technical data:

Bracket

Material	EN-AW-6063 T66
Yield strength	200 N/mm ²
Modulus of elasticity	70.000 N/mm ²
Isolator material	Polypropylene
Thermal conductivity polypropylene	0.117 W/mK
Thermal conductivity aluminum	160 W/mK

Substrate

Material	Thick standard brick
Thickness d_v	300 mm
Thermal conductivity λ_w	0.44 W/mK
Thermal resistance R_v	0.682 W/mK

Insulation

Material	Mineral wool
Thickness d_D	50-300 mm
Thermal conductivity λ_D	0.035 W/mK

MFT- FOX VI Medium Brackets			FOX-VI 80 M	FOX-VI 100 M	FOX-VI 120 M	FOX-VI 140 M	FOX-VI 160 M	FOX-VI 180 M	FOX-VI 200 M	FOX-VI 220 M	FOX-VI 240 M	FOX-VI 260 M	FOX-VI 280 M	FOX-VI 300 M
Insulation thickness	d_D	[mm]	50	70	100	120	140	160	180	200	220	240	250	300
Thermal transmission coefficient of the undisturbed wall	U_0	[W/m ² K]	0.4218	0.3399	0.2632	0.2288	0.2023	0.1814	0.1643	0.1502	0.1384	0.1282	0.1237	0.1051
Punctual thermal bridge loss coefficient of the bracket	χ	[W/K]	0.0139	0.018	0.022	0.0236	0.0245*	0.0254	0.026*	0.0266	0.0269*	0.0272*	0.0274	0.0275

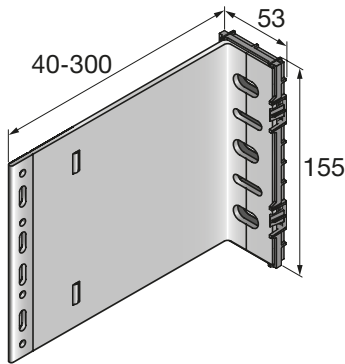
*value interpolated

U-Value**

(surface A=1.0 m², profile length 1.0 m, profile 30 mm air side)

Number of brackets	1	0.4357	0.3579	0.2852	0.2524	0.2268	0.2068	0.1903	0.1768	0.1653	0.1554	0.1511	0.1326
Number of brackets	2	0.4496	0.3759	0.3072	0.2760	0.2513	0.2322	0.2163	0.2034	0.1922	0.1826	0.1785	0.1601
Number of brackets	3	0.4635	0.3939	0.3292	0.2996	0.2758	0.2576	0.2423	0.2300	0.2191	0.2098	0.2059	0.1876
Number of brackets	4	0.4774	0.4119	0.3512	0.3232	0.3003	0.2830	0.2683	0.2566	0.2460	0.2370	0.2333	0.2151
Number of brackets	5	0.4913	0.4299	0.3732	0.3468	0.3248	0.3084	0.2943	0.2832	0.2729	0.2642	0.2607	0.2426

**MFT-FOX V M and profile T 120 x 60 x 1.8 30 inside the insulation



MFT-FOX VI L – CONCRETE 180 MM

Technical data:

Bracket

Material	EN-AW-6063 T66
Yield strength	200 N/mm ²
Modulus of elasticity	70.000 N/mm ²
Isolator material	Polypropylene
Thermal conductivity polypropylene	0.117 W/mK
Thermal conductivity aluminum	160 W/mK

Substrate

Material	Concrete
Thickness d_v	180 mm
Thermal conductivity λ_w	1.8 W/mK
Thermal resistance R_v	0.1 W/mK

Insulation

Material	Mineral wool
Thickness d_D	50-300 mm
Thermal conductivity λ_D	0.035 W/mK

MFT- FOX VI Large Brackets			FOX-VI 80 L	FOX-VI 100 L	FOX-VI 120 L	FOX-VI 140 L	FOX-VI 160 L	FOX-VI 180 L	FOX-VI 200 L	FOX-VI 220 L	FOX-VI 240 L	FOX-VI 260 L	FOX-VI 280 L	FOX-VI 300 L
Insulation thickness	d_D	[mm]	100	120	100	120	140	160	180	200	220	240	250	300
Thermal transmission coefficient of the undisturbed wall	U_0	[W/m ² K]	0.5591	0.4237	0.3108	0.2640	0.2294	0.2028	0.1817	0.1646	0.1505	0.1386	0.1333	0.1120
Punctual thermal bridge loss coefficient of the bracket	χ	[W/K]	0.0629	0.07	0.0736	0.0735	0.0738*	0.0741	0.0736*	0.073	0.0725*	0.072*	0.0717	0.0685

*value interpolated

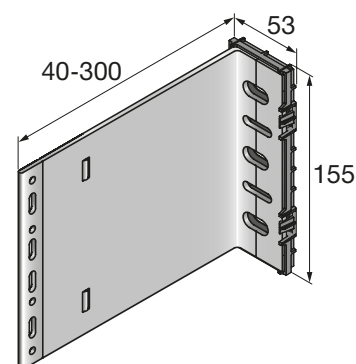
U-Value**

(surface A=1.0 m², profile length 1.0 m, profile 30 mm air side)

Number of brackets	1	0.6220	0.4937	0.3844	0.3375	0.3032	0.2769	0.2553	0.2376	0.2230	0.2106	0.2050	0.1805
Number of brackets	2	0.6849	0.5637	0.4580	0.4110	0.3770	0.3510	0.3289	0.3106	0.2955	0.2826	0.2767	0.2490
Number of brackets	3	0.7478	0.6337	0.5316	0.4845	0.4508	0.4251	0.4025	0.3836	0.3680	0.3546	0.3484	0.3175
Number of brackets	4	0.8107	0.7037	0.6052	0.5580	0.5246	0.4992	0.4761	0.4566	0.4405	0.4266	0.4201	0.3860
Number of brackets	5	0.8736	0.7737	0.6788	0.6315	0.5984	0.5733	0.5497	0.5296	0.5130	0.4986	0.4918	0.4545

**MFT-FOX V L and profile T 120 x 60 x 1.8 30 inside the insulation

MFT-FOX VI L – THICK STANDARD BRICK 300 MM



Technical data:

Bracket

Material	EN-AW-6063 T66
Yield strength	200 N/mm ²
Modulus of elasticity	70.000 N/mm ²
Isolator material	Polypropylene
Thermal conductivity polypropylene	0.117 W/mK
Thermal conductivity aluminum	160 W/mK

Substrate

Material	Thick standard brick
Thickness d_v	300 mm
Thermal conductivity λ_w	0.44 W/mK
Thermal resistance R_v	0.682 W/mK

Insulation

Material	Mineral wool
Thickness d_D	50-300 mm
Thermal conductivity λ_D	0.035 W/mK

MFT- FOX VI Large Brackets			FOX-VI 80 L	FOX-VI 100 L	FOX-VI 120 L	FOX-VI 140 L	FOX-VI 160 L	FOX-VI 180 L	FOX-VI 200 L	FOX-VI 220 L	FOX-VI 240 L	FOX-VI 260 L	FOX-VI 280 L	FOX-VI 300 L
Insulation thickness	d_D	[mm]	50	70	100	120	140	160	180	200	220	240	250	300
Thermal transmission coefficient of the undisturbed wall	U_0	[W/m ² K]	0.4218	0.3399	0.2632	0.2288	0.2023	0.1814	0.1643	0.1502	0.1384	0.1282	0.1237	0.1051
Punctual thermal bridge loss coefficient of the bracket	χ	[W/K]	0.0231	0.0263	0.0342	0.0366	0.0379	0.0393	0.0400	0.0413	0.0419	0.0425	0.0428	0.0431

*value interpolated

U-Value**

(surface A=1.0m², profile TT100x100x2.0 mm, profile 30 mm into the insulation)

Number of brackets	1	0.4449	0.3662	0.2974	0.2654	0.2402	0.2207	0.2043	0.1915	0.1803	0.1707	0.1665	0.1482
Number of brackets	2	0.4680	0.3925	0.3316	0.3020	0.2781	0.2600	0.2443	0.2328	0.2222	0.2132	0.2093	0.1913
Number of brackets	3	0.4911	0.4188	0.3658	0.3386	0.3160	0.2993	0.2843	0.2741	0.2641	0.2557	0.2521	0.2344
Number of brackets	4	0.5142	0.4451	0.4000	0.3752	0.3539	0.3386	0.3243	0.3154	0.3060	0.2982	0.2949	0.2775
Number of brackets	5	0.5373	0.4714	0.4342	0.4118	0.3918	0.3779	0.3643	0.3567	0.3479	0.3407	0.3377	0.3206

**MFT-FOX V L and profile T 120 x 60 x 1.8 30 inside the insulation



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