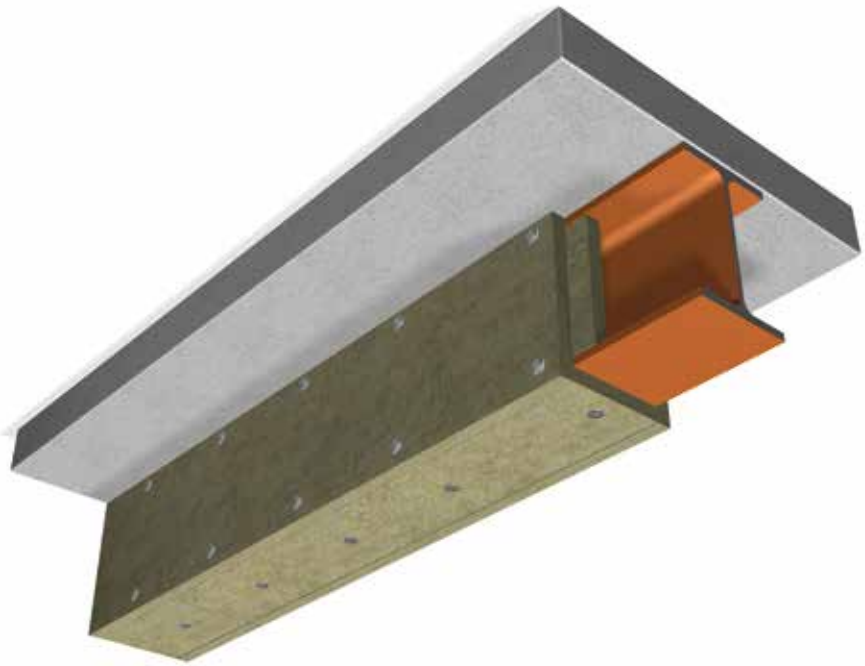
FIRE PROTECTION GUIDE 1/STEEL

LOADBEARING STEEL BEAMS & COLUMNS, STEEL TRAPEZOID ROOFS



OWENS CORNING® PAROC®

CONTENT:

1. LOADBEARING STEEL BEAMS AND COLUMNS

The fire resistance requirement for a building is defined in terms of the fire resistance period and stated in terms of minutes (15, 30, 45, 60, 75, 90, 120, etc. up to 240 minutes). This information is usually given in local building regulations and it depends on the height, occupants and type of building.

In practice, this means that the building frame has to maintain its load-bearing capacity during a fire until everybody has left the burning building. It is the responsibility of the design engineer, to specify the relevant limiting or failure temperature for a given section.

Different load-bearing materials have different fire resistance periods. These materials are usually tested by using a standard fire curve that presents the development of a real fire. The temperature in a standard fire rises relatively quickly and then increases indefinitely.

Fire resistance test results are expressed in terms of time of failure against one or more of three criteria:

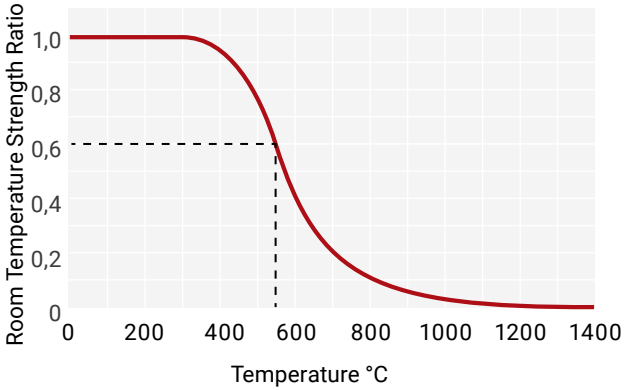
- Load-bearing capacity (R)
- Integrity (passage of hot gases/flames) (E)
- Insulation (temperature rise on the cold side of the structural element, usually max 140 °C) (I

In some building constructions, all of these are needed; however, for steel frames only the load-bearing capacity is required, e.g., R120.

DETERMINE THE STEEL'S CRITICAL TEMPERATURE AND SECTION FACTOR

All materials lose their strength as they heat up.

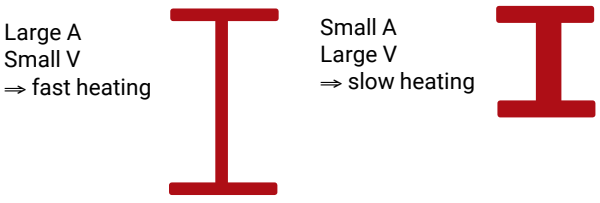
- Fully loaded steel beams exposed on four sides, fail at 550 °C, regardless of steel grade.
- Fully loaded beams exposed on three sides, fail at 620 °C.
- => The temperature 450–500 °C is commonly used as relatively safe limit value.



Fires in buildings frequently exceed 1000 degrees Centigrade within a relatively short period of time (30–60 minutes), yet heavily loaded steel loses its design safety margin, approx. 40%, at temperatures around 550°C, regardless of the grade. As the temperature rises further, the loss of strength is rapid and significant.

For this reason, the fire protection design is based on this limiting temperature for elements exposed to fire on four sides. The aim is to keep the steel temperature below its critical temperature.

The rate of increase in the temperature of a steel cross-section is determined by the ratio of the heated surface area (Am) to the volume (V). This ratio, (Am /V), is given in units of m^{-1} and is known as the section factor. Members with low section factors will heat up more slowly. Thus, the section factor is a measure of the rate at which a section will heat up in a fire and the higher its value, the greater the protection thickness required.



A steel section with a large surface area (A) (m^2/m) will receive more heat than one with a smaller surface area. In addition, the greater the volume (V) (m^3/m) of the section, the greater the heat sink. It therefore follows, that the temperature of a small thick section will increase slower than for a large thin one.

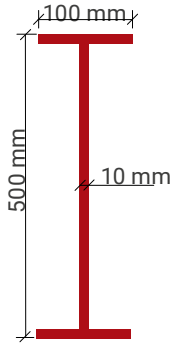
In calculating the section factor values, the full volume, V, is used whether the section is exposed on three or four sides, since the entire steel section will be receiving heat. However, A is the exposed surface area and it depends on the configuration of the fire protection.

Example of calculating section factor Am/V

- Surface area (Am) of one-meter-long beam is 1.38 m²
- Volume (V) of one-meter-long beam is 0.0068 m³)

A / V = 1.38 / 0.0068 = 203 m^{-1}

Section factors vary, in general, from 25 m^{-1} for very large sections to over 300 m^{-1} for small, slender sections.

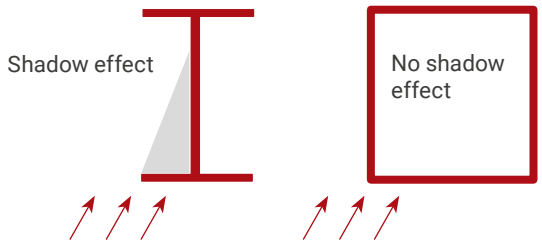


Unprotected steel

Shadow effect

In the case of unprotected steel profiles, a section factor including the shadow effect can be considered. Shadow effects are caused by local shielding of irradiative heat transfer, due to the shape of the steel profile, e.g.

- I-profiles: $k_{shadow} = 0.9\ [A_m/V]_{box} / [A_m/V]$
- □-profiles: $k_{shadow} = 1$
- Insulated profiles = 1 (all)



Whilst the section factor can be calculated, it is more usual to refer to the various steel manufacturers' profile information, where this value is given.

DETERMINE PROTECTION METHOD

The most practical way to limit the rise in steel temperature is to insulate it from the fire. When considering any fire protection system, it is important to distinguish between profile, box and solid application methods.

Profile Box Solid

Sprayed materials are normally applied to follow the profile of the section. Special insulating concretes can be used to form solid protection.

Slab materials are normally used to form a box around the section or with higher profiles following the profile.

The type of insulation has to be taken into account when designing steel structures, because the insulation also conducts heat. In the case of protected members, the section factor A_p /V is multiplied by a factor, allowing for the thermal conductivity of the protection material, divided by its thickness λ_p /d_p.

$$(A_p/V) \times (\lambda_p/d_p)$$

Summary:

The thickness of the fire protection insulation required depends on

- the duration of fire resistance specified in national regulations (R30, R60, R90, R120…)
- the steel's critical temperature and section factor
  –> perimeter of the steel section exposed to fire (A)
  –> shape and size of the steel section (total volume, V)
- type of protection used

FIRE PROTECTION OF STEEL PROFILES WITH PAROC FPS 17

Design tools for calculating the thickness of the stone wool fire protection board have been developed for 30–240 minutes endurance time in a Standard Fire Exposure (R30–R240) for open and closed (I/H and RHS) steel sections.

Based on graphical or tabulated design values, PAROC FPS 17 board thicknesses can be chosen as a function of

- fire endurance time,
- section factor A/V for the member and
- Critical steel temperature ranging from 300–700°C

A_p /V – SECTION FACTOR FOR PROTECTED MEMBERS

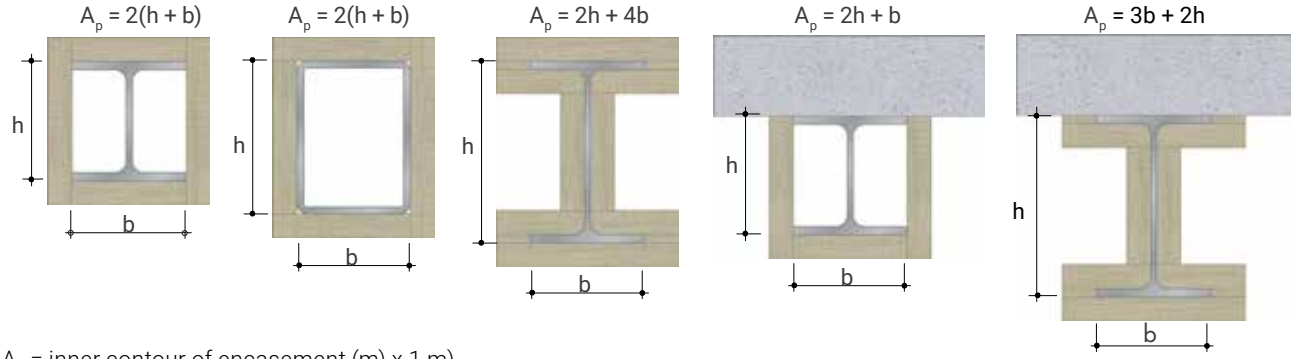
Section factor for insulated steel members:

A /V = (m^{-1})

For "box" protection, the surface area is taken as the sum of the inside dimensions of the smallest possible rectangular or square encasement.

RHS = rectangular hollow section

When the height of the I profile is greater than 450 mm, the insulation has to be fitted following the profile.



A_p = inner contour of encasement (m) x 1 m)
V = cross-section area of steel profile (m^2) x 1 m)

Calculation example

Steel beam, encased on three sides

- Serial size: 406 mm x 178 mm x 54 kg/m
- Actual size: 402.6 mm x 177.6 mm

A = 2h + b –> 402.6 + 402.6 + 177.6 = 982.8 mm × 1000 mm = 0.9828 m^2
V = 0.00684 m^3

A/V = 0.9828 m^2/0.00684 m^3 = 143.7 m^{-1} = 144 m^{-1}

or

A/V = (ρ × A)/W = 7850 kg/m^3 × 0.9828 m^2/54 kg/m = 143 m^{-1}

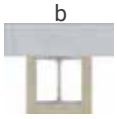
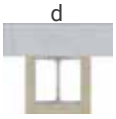
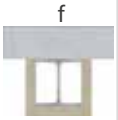
W =Mass of steel section per meter (kg/m)

(The nominal density of steel is 7850 kg/m^3. The value of W can be obtained either from steelwork tables or by accurate measurement.)
Once the specific A/V value is known, the required thickness of the PAROC FPS 17 board for the defined fire protection can be found from the A/V tables.

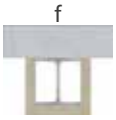
You can also use ready-calculated A_p /V values from the profile manufacturers:

1. Find the section factor A_p/V by using the steel profile data for the steel profile from the steel supplier. For example, section factor for HE 140 B exposed on four sides profile is 130 m^{-1}.
2. In the following figures, you can find the fire class and the required insulation thickness. Choose the table based on the required fire resistance time, check the critical temperature and read off the PAROC FPS 17 thickness from the section factor row. For example, if critical temperature for the steel profile is 450°C and required fire resistance time is 30 minutes, you need 20 mm PAROC FPS 17 fire protection for a section factor of 130 m^{-1}.

1.1 Section factors for H-profiles

HEA-profile			HEB-profile			HEM-profile		
	a	b		c	d		e	f
								
	a	b		c	d		e	f
	A_P/V (m^{-1})	A/V (m^{-1})		A_P/V (m^{-1})	A_P/V (m^{-1})		A_P/V (m^{-1})	A_P/V (m^{-1})
HE 100 A	184	138	HE 100 B	154	115	HE 100 M	85	65
HE 120 A	185	137	HE 120 B	141	106	HE 120 B	80	61
HE 140 A	174	129	HE 140 B	130	98	HE 140 M	76	58
HE 160 A	161	120	HE 160 B	118	89	HE 160 M	71	54
HE 180 A	155	115	HE 180 B	110	83	HE 180 M	68	52
HE 200 A	145	108	HE 200 B	103	77	HE 200 M	65	49
HE 220 A	134	100	HE 220 B	97	73	HE 220 M	62	47
HE 240 A	122	91	HE 240 B	91	68	HE 240 M	52	40
HE 260 A	118	88	HE 260 B	88	66	HE 260 M	51	39
HE 280 A	113	84	HE 280 B	85	64	HE 280 M	50	38
HE 300 A	105	78	HE 300 B	81	60	HE 300 M	43	33
HE 320 A	98	74	HE 320 B	77	58			
HE 340 A	94	72	HE 340 B	75	57			
HE 360 A	91	70	HE 360 B	73	57			
HE 400 A	87	68	HE 400 B	71	56			
HE 450 A	83	66	HE 450 B	69	55			
HE 500 A	80	65	HE 500 B	67	55			
HE 550 A	79	65	HE 550 B	67	55			
HE 600 A	79	65	HE 600 B	67	56			
HE 650 A	79	65	HE 650 B	66	56			

1.2 Section factors for IPE-profile

IPE-profile		
	e	f
		
	e	f
	A_P/V (m^{-1})	A_P/V (m^{-1})
80	330	270
100	300	247
120	279	230
140	259	215
160	241	200
180	226	188
200	211	176
220	198	165
240	184	153
270	176	147
300	167	139
330	157	131
360	146	122
400	137	116
450	130	110
500	151	139
550	140	129
600	129	119

Box installation *Profile installation*

The insulation thicknesses given in the tables are based on a designed program of fire tests on both loaded and unloaded specimens and a mathematical procedure applied to the results of the tests. The test programs were designed to determine both the insulation characteristics of a fire protection material and its physical performance under fire conditions for a range of steel sizes.

Steel sections protected with PAROC FPS 17 were tested and calculated according to EN 1363-1:2012 and ENV 13381-4:2013 in the Danish Institute of Fire and Security Technology (DBI), Denmark. This system has a European Technical Approval issued by VTT Expert Services (ETA 08/0093).

1.3 Insulation thickness for R30 steel structure A/V 130, critical steel temperature 450 °C

Fire resistance period 30 minutes									
Design temperature [°C]	**300**	**350**	**400**	**450**	**500**	**550**	**600**	**650**	**700**
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	20	20	20	20	20	20	20	20	20
50	20	20	20	20	20	20	20	20	20
55	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20
65	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20
75	20	20	20	20	20	20	20	20	20
80	20	20	20	20	20	20	20	20	20
85	20	20	20	20	20	20	20	20	20
90	20	20	20	20	20	20	20	20	20
95	20	20	20	20	20	20	20	20	20
100	20	20	20	20	20	20	20	20	20
105	20	20	20	20	20	20	20	20	20
110	20	20	20	20	20	20	20	20	20
115	20	20	20	20	20	20	20	20	20
120	20	20	20	20	20	20	20	20	20
125	20	20	20	20	20	20	20	20	20
130	20	20	20	20	20	20	20	20	20
135	20	20	20	20	20	20	20	20	20
140	20	20	20	20	20	20	20	20	20
145	20	20	20	20	20	20	20	20	20
150	20	20	20	20	20	20	20	20	20
155	20	20	20	20	20	20	20	20	20
160	20	20	20	20	20	20	20	20	20
165	20	20	20	20	20	20	20	20	20
170	20	20	20	20	20	20	20	20	20
175	20	20	20	20	20	20	20	20	20
180	20	20	20	20	20	20	20	20	20
185	20	20	20	20	20	20	20	20	20
190	20	20	20	20	20	20	20	20	20
195	20	20	20	20	20	20	20	20	20
200	25	20	20	20	20	20	20	20	20
205	25	20	20	20	20	20	20	20	20
210	25	20	20	20	20	20	20	20	20
215	25	20	20	20	20	20	20	20	20
220	25	20	20	20	20	20	20	20	20
225	25	20	20	20	20	20	20	20	20
230	25	20	20	20	20	20	20	20	20
235	25	20	20	20	20	20	20	20	20
240	25	20	20	20	20	20	20	20	20
245	30	20	20	20	20	20	20	20	20
250	30	20	20	20	20	20	20	20	20
255	30	20	20	20	20	20	20	20	20
260	30	20	20	20	20	20	20	20	20
265	30	20	20	20	20	20	20	20	20
270	30	20	20	20	20	20	20	20	20
275	30	20	20	20	20	20	20	20	20
280	30	20	20	20	20	20	20	20	20
281	30	25	20	20	20	20	20	20	20

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2. OPEN AND CLOSED STEEL SECTIONS

With a profile height of 0 < h ≤ 600 mm
Design tables for installation with welding pins

2.1 Insulation thickness for R60 steel structure

Fire resistance period 60 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	20	20	20	20	20	20	20	20	20
50	20	20	20	20	20	20	20	20	20
55	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20
65	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20
75	20	20	20	20	20	20	20	20	20
80	20	20	20	20	20	20	20	20	20
85	20	20	20	20	20	20	20	20	20
90	25	20	20	20	20	20	20	20	20
95	25	20	20	20	20	20	20	20	20
100	25	20	20	20	20	20	20	20	20
105	30	20	20	20	20	20	20	20	20
110	30	25	20	20	20	20	20	20	20
115	30	25	20	20	20	20	20	20	20
120	30	25	20	20	20	20	20	20	20
125	40	25	20	20	20	20	20	20	20
130	40	30	20	20	20	20	20	20	20
135	40	30	20	20	20	20	20	20	20
140	40	30	25	20	20	20	20	20	20
145	40	30	25	20	20	20	20	20	20
150	40	30	25	20	20	20	20	20	20
155	40	40	25	20	20	20	20	20	20
160	40	40	30	20	20	20	20	20	20
165	40	40	30	20	20	20	20	20	20
170	50	40	30	25	20	20	20	20	20
175	50	40	30	25	20	20	20	20	20
180	50	40	30	25	20	20	20	20	20
185	50	40	30	25	20	20	20	20	20
190	50	40	30	25	20	20	20	20	20
195	50	40	40	25	20	20	20	20	20
200	50	40	40	25	20	20	20	20	20
205	50	40	40	30	20	20	20	20	20
210	50	40	40	30	25	20	20	20	20
215	50	50	40	30	25	20	20	20	20
220	60	50	40	30	25	20	20	20	20
225	60	50	40	30	25	20	20	20	20
230	60	50	40	30	25	20	20	20	20
235	60	50	40	30	25	20	20	20	20
240	60	50	40	30	25	20	20	20	20
245	60	50	40	30	25	20	20	20	20
250	60	50	40	30	25	20	20	20	20
255	60	50	40	40	25	20	20	20	20
260	60	50	40	40	30	25	20	20	20
265	60	50	40	40	30	25	20	20	20
270	60	50	40	40	30	25	20	20	20
275	-	50	40	40	30	25	20	20	20
280	-	50	40	40	30	25	20	20	20
281	-	50	40	40	30	25	20	20	20

2.2 Insulation thickness for R90 steel structure

Fire resistance period 90 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	20	20	20	20	20	20	20	20	20
50	20	20	20	20	20	20	20	20	20
55	20	20	20	20	20	20	20	20	20
60	25	20	20	20	20	20	20	20	20
65	25	20	20	20	20	20	20	20	20
70	30	25	20	20	20	20	20	20	20
75	30	25	20	20	20	20	20	20	20
80	40	30	20	20	20	20	20	20	20
85	40	30	25	20	20	20	20	20	20
90	40	30	25	20	20	20	20	20	20
95	40	40	30	20	20	20	20	20	20
100	40	40	30	25	20	20	20	20	20
105	50	40	30	25	20	20	20	20	20
110	50	40	40	30	20	20	20	20	20
115	50	40	40	30	25	20	20	20	20
120	50	50	40	30	25	20	20	20	20
125	50	50	40	30	25	20	20	20	20
130	50	50	40	40	30	20	20	20	20
135	60	50	40	40	30	25	20	20	20
140	60	50	40	40	30	25	20	20	20
145	60	50	50	40	30	25	20	20	20
150	60	50	50	40	40	25	20	20	20
155	60	60	50	40	40	30	25	20	20
160	60	60	50	40	40	30	25	20	20
165	-	60	50	40	40	30	25	20	20
170	-	60	50	40	40	30	25	20	20
175	-	60	50	50	40	30	25	20	20
180	-	60	50	50	40	30	25	25	20
185	-	60	50	50	40	40	30	25	20
190	-	60	50	50	40	40	30	25	20
195	-	60	60	50	40	40	30	25	20
200	-	-	60	50	40	40	30	25	20
205	-	-	60	50	40	40	30	25	20
210	-	-	60	50	40	40	30	25	20
215	-	-	60	50	40	40	30	25	25
220	-	-	60	50	40	40	30	30	25
225	-	-	60	50	50	40	30	30	25
230	-	-	60	50	50	40	40	30	25
235	-	-	60	50	50	40	40	30	25
240	-	-	60	50	50	40	40	30	25
245	-	-	60	50	50	40	40	30	25
250	-	-	60	50	50	40	40	30	25
255	-	-	60	50	50	40	40	30	25
260	-	-	60	50	50	40	40	30	25
265	-	-	60	60	50	40	40	30	25
270	-	-	-	60	50	40	40	30	30
275	-	-	-	60	50	40	40	30	30
280	-	-	-	60	50	40	40	30	30
281	-	-	-	60	50	40	40	30	30

With a profile height of 0 < h ≤ 600 mm
Design tables for installation with welding pins

2.3 Insulation thickness for R120 steel structure

Fire resistance period 120 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	25	20	20	20	20	20	20	20	20
50	30	25	20	20	20	20	20	20	20
55	30	25	20	20	20	20	20	20	20
60	40	30	25	20	20	20	20	20	20
65	40	40	30	20	20	20	20	20	20
70	40	40	30	25	20	20	20	20	20
75	50	40	40	30	20	20	20	20	20
80	50	40	40	30	25	20	20	20	20
85	50	50	40	40	30	20	20	20	20
90	50	50	40	40	30	25	20	20	20
95	60	50	50	40	40	25	20	20	20
100	60	50	50	40	40	30	20	20	20
105	60	60	50	40	40	30	25	20	20
110	60	60	50	50	40	40	25	20	20
115	-	60	50	50	40	40	30	25	20
120	-	60	60	50	40	40	30	25	20
125	-	60	60	50	50	40	30	25	20
130	-	-	60	50	50	40	40	30	25
135	-	-	60	50	50	40	40	30	25
140	-	-	60	60	50	40	40	30	25
145	-	-	60	60	50	40	40	30	25
150	-	-	60	60	50	50	40	40	30
155	-	-	-	60	50	50	40	40	30
160	-	-	-	60	50	50	40	40	30
165	-	-	-	60	50	50	40	40	30
170	-	-	-	60	50	50	40	40	30
175	-	-	-	60	60	50	40	40	30
180	-	-	-	60	60	50	40	40	40
185	-	-	-	60	60	50	50	40	40
190	-	-	-	-	60	50	50	40	40
195	-	-	-	-	60	50	50	40	40
200	-	-	-	-	60	50	50	40	40
205	-	-	-	-	60	50	50	40	40
210	-	-	-	-	60	50	50	40	40
215	-	-	-	-	60	50	50	40	40
220	-	-	-	-	60	50	50	40	40
225	-	-	-	-	60	50	50	40	40
230	-	-	-	-	60	60	50	40	40
235	-	-	-	-	60	60	50	40	40
240	-	-	-	-	60	60	50	50	40
245	-	-	-	-	60	60	50	50	40
250	-	-	-	-	60	60	50	50	40
255	-	-	-	-	60	60	50	50	40
260	-	-	-	-	60	60	50	50	40
265	-	-	-	-	-	60	50	50	40
270	-	-	-	-	-	60	50	50	40
275	-	-	-	-	-	60	50	50	40
280	-	-	-	-	-	60	50	50	40
281	-	-	-	-	-	60	50	50	40

2.4 Insulation thickness for R150 steel structure

Fire resistance period 150 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	40	30	25	20	20	20	20	20	20
50	40	30	30	20	20	20	20	20	20
55	40	40	30	25	20	20	20	20	20
60	50	40	40	30	25	20	20	20	20
65	50	50	40	40	30	20	20	20	20
70	50	50	50	40	40	25	20	20	20
75	60	50	50	40	40	30	25	20	20
80	60	60	50	50	40	40	30	20	20
85	60	60	50	50	50	40	30	25	20
90	-	60	60	50	50	40	40	30	20
95	-	60	60	50	50	40	40	30	25
100	-	-	60	60	50	50	40	40	25
105	-	-	60	60	50	50	40	40	30
110	-	-	-	60	60	50	50	40	30
115	-	-	-	60	60	50	50	40	40
120	-	-	-	-	60	50	50	40	40
125	-	-	-	-	60	60	50	40	40
130	-	-	-	-	60	60	50	50	40
135	-	-	-	-	60	60	50	50	40
140	-	-	-	-	60	60	50	50	40
145	-	-	-	-	-	60	50	50	40
150	-	-	-	-	-	60	50	50	40
155	-	-	-	-	-	60	60	50	50
160	-	-	-	-	-	60	60	50	50
165	-	-	-	-	-	60	60	50	50
170	-	-	-	-	-	60	60	50	50
175	-	-	-	-	-	60	60	50	50
180	-	-	-	-	-	-	60	50	50
185	-	-	-	-	-	-	60	50	50
190	-	-	-	-	-	-	60	50	50
195	-	-	-	-	-	-	60	50	50
200	-	-	-	-	-	-	60	60	50
205	-	-	-	-	-	-	60	60	50
210	-	-	-	-	-	-	60	60	50
215	-	-	-	-	-	-	60	60	50
220	-	-	-	-	-	-	60	60	50
225	-	-	-	-	-	-	60	60	50
230	-	-	-	-	-	-	60	60	50
235	-	-	-	-	-	-	60	60	50
240	-	-	-	-	-	-	60	60	50
245	-	-	-	-	-	-	60	60	50
250	-	-	-	-	-	-	60	60	50
255	-	-	-	-	-	-	60	60	50
260	-	-	-	-	-	-	-	60	50
265	-	-	-	-	-	-	-	60	50
270	-	-	-	-	-	-	-	60	50
275	-	-	-	-	-	-	-	60	50
280	-	-	-	-	-	-	-	60	50
281	-	-	-	-	-	-	-	60	50

With a profile height of 0 < h ≤ 600 mm
Design tables for installation with welding pins

2.5 Insulation thickness for R180 steel structure

Fire resistance period 180 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	40	40	40	30	20	20	20	20	20
50	50	40	40	40	25	20	20	20	20
55	50	50	40	40	40	25	20	20	20
60	60	50	50	50	40	30	25	20	20
65	60	60	50	50	50	40	30	20	20
70	60	60	60	50	50	40	40	30	20
75	-	60	60	60	50	50	40	40	25
80	-	-	60	60	60	50	50	40	30
85	-	-	-	60	60	50	50	40	40
90	-	-	-	-	60	60	50	50	40
95	-	-	-	-	60	60	50	50	40
100	-	-	-	-	-	60	60	50	50
105	-	-	-	-	-	60	60	50	50
110	-	-	-	-	-	-	60	50	50
115	-	-	-	-	-	-	60	60	50
120	-	-	-	-	-	-	60	60	50
125	-	-	-	-	-	-	60	60	50
130	-	-	-	-	-	-	-	60	50
135	-	-	-	-	-	-	-	60	60
140	-	-	-	-	-	-	-	60	60
145	-	-	-	-	-	-	-	60	60
150	-	-	-	-	-	-	-	60	60
155	-	-	-	-	-	-	-	60	60
160	-	-	-	-	-	-	-	60	60
165	-	-	-	-	-	-	-	60	60
170	-	-	-	-	-	-	-	-	60
175	-	-	-	-	-	-	-	-	60
180	-	-	-	-	-	-	-	-	60
185	-	-	-	-	-	-	-	-	60
190	-	-	-	-	-	-	-	-	60
195	-	-	-	-	-	-	-	-	60
200	-	-	-	-	-	-	-	-	60
205	-	-	-	-	-	-	-	-	60
210	-	-	-	-	-	-	-	-	60
215	-	-	-	-	-	-	-	-	60
220	-	-	-	-	-	-	-	-	60
225	-	-	-	-	-	-	-	-	60
230	-	-	-	-	-	-	-	-	60
235	-	-	-	-	-	-	-	-	60
240	-	-	-	-	-	-	-	-	60
245	-	-	-	-	-	-	-	-	60
250	-	-	-	-	-	-	-	-	60
255	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-
265	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-
275	-	-	-	-	-	-	-	-	-
280	-	-	-	-	-	-	-	-	-
281	-	-	-	-	-	-	-	-	-

2.6 Insulation thickness for R210 steel structure

Fire resistance period 210 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	50	50	50	40	40	30	20	20	20
50	50	50	50	50	40	40	25	20	20
55	60	60	50	50	50	40	40	25	20
60	60	60	60	60	50	50	40	40	25
65	-	-	60	60	60	50	50	40	40
70	-	-	-	-	60	60	50	50	40
75	-	-	-	-	-	60	60	50	50
80	-	-	-	-	-	-	60	60	50
85	-	-	-	-	-	-	60	60	50
90	-	-	-	-	-	-	-	60	60
95	-	-	-	-	-	-	-	60	60
100	-	-	-	-	-	-	-	-	60
105	-	-	-	-	-	-	-	-	60
110	-	-	-	-	-	-	-	-	60
115	-	-	-	-	-	-	-	-	60
120	-	-	-	-	-	-	-	-	-
125	-	-	-	-	-	-	-	-	-
130	-	-	-	-	-	-	-	-	-
135	-	-	-	-	-	-	-	-	-

2.7 Insulation thickness for R240 steel structure

Fire resistance period 240 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	60	60	50	50	50	50	40	25	20
50	60	60	60	60	50	50	50	40	20
55	-	-	60	60	60	60	50	50	40
60	-	-	-	-	-	60	60	60	50
65	-	-	-	-	-	-	-	60	60
70	-	-	-	-	-	-	-	-	60
75	-	-	-	-	-	-	-	-	60
80	-	-	-	-	-	-	-	-	-

3. OPEN AND CLOSED STEEL SECTIONS

With a profile height of 0 < h ≤ 600 mm
Design tables for installation with fire springs

3.1 Insulation thickness for R30 steel structure

Fire resistance period 30 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	20	20	20	20	20	20	20	20	20
50	20	20	20	20	20	20	20	20	20
55	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20
65	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20
75	20	20	20	20	20	20	20	20	20
80	20	20	20	20	20	20	20	20	20
85	20	20	20	20	20	20	20	20	20
90	20	20	20	20	20	20	20	20	20
95	20	20	20	20	20	20	20	20	20
100	20	20	20	20	20	20	20	20	20
105	20	20	20	20	20	20	20	20	20
110	20	20	20	20	20	20	20	20	20
115	20	20	20	20	20	20	20	20	20
120	20	20	20	20	20	20	20	20	20
125	20	20	20	20	20	20	20	20	20
130	20	20	20	20	20	20	20	20	20
135	20	20	20	20	20	20	20	20	20
140	20	20	20	20	20	20	20	20	20
145	20	20	20	20	20	20	20	20	20
150	20	20	20	20	20	20	20	20	20
155	20	20	20	20	20	20	20	20	20
160	20	20	20	20	20	20	20	20	20
165	20	20	20	20	20	20	20	20	20
170	20	20	20	20	20	20	20	20	20
175	20	20	20	20	20	20	20	20	20
180	25	20	20	20	20	20	20	20	20
185	25	20	20	20	20	20	20	20	20
190	25	20	20	20	20	20	20	20	20
195	25	20	20	20	20	20	20	20	20
200	25	20	20	20	20	20	20	20	20
205	25	20	20	20	20	20	20	20	20
210	25	20	20	20	20	20	20	20	20
215	25	20	20	20	20	20	20	20	20
220	25	20	20	20	20	20	20	20	20
225	30	20	20	20	20	20	20	20	20
230	30	20	20	20	20	20	20	20	20
235	30	20	20	20	20	20	20	20	20
240	30	25	20	20	20	20	20	20	20
245	30	25	20	20	20	20	20	20	20
250	30	25	20	20	20	20	20	20	20
255	30	25	20	20	20	20	20	20	20
260	30	25	20	20	20	20	20	20	20
265	30	25	20	20	20	20	20	20	20
270	30	25	20	20	20	20	20	20	20
275	30	25	20	20	20	20	20	20	20
280	40	25	20	20	20	20	20	20	20
281	40	25	20	20	20	20	20	20	20

3.2 Insulation thickness for R60 steel structure

Fire resistance period 60 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	20	20	20	20	20	20	20	20	20
50	20	20	20	20	20	20	20	20	20
55	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20
65	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20
75	20	20	20	20	20	20	20	20	20
80	25	20	20	20	20	20	20	20	20
85	25	20	20	20	20	20	20	20	20
90	25	20	20	20	20	20	20	20	20
95	30	25	20	20	20	20	20	20	20
100	30	25	20	20	20	20	20	20	20
105	30	25	20	20	20	20	20	20	20
110	40	25	20	20	20	20	20	20	20
115	40	30	25	20	20	20	20	20	20
120	40	30	25	20	20	20	20	20	20
125	40	30	25	20	20	20	20	20	20
130	40	30	25	20	20	20	20	20	20
135	40	40	25	20	20	20	20	20	20
140	40	40	30	25	20	20	20	20	20
145	40	40	30	25	20	20	20	20	20
150	50	40	30	25	20	20	20	20	20
155	50	40	30	25	20	20	20	20	20
160	50	40	30	25	20	20	20	20	20
165	50	40	40	30	25	20	20	20	20
170	50	40	40	30	25	20	20	20	20
175	50	40	40	30	25	20	20	20	20
180	50	40	40	30	25	20	20	20	20
185	50	50	40	30	25	20	20	20	20
190	60	50	40	30	25	20	20	20	20
195	60	50	40	30	25	25	20	20	20
200	60	50	40	40	30	25	20	20	20
205	60	50	40	40	30	25	20	20	20
210	60	50	40	40	30	25	20	20	20
215	60	50	40	40	30	25	20	20	20
220	60	50	40	40	30	25	20	20	20
225	60	50	40	40	30	25	20	20	20
230	60	50	50	40	30	25	20	20	20
235	60	50	50	40	30	25	25	20	20
240	60	50	50	40	30	25	25	20	20
245	-	60	50	40	30	30	25	20	20
250	-	60	50	40	40	30	25	20	20
255	-	60	50	40	40	30	25	20	20
260	-	60	50	40	40	30	25	20	20
265	-	60	50	40	40	30	25	20	20
270	-	60	50	40	40	30	25	20	20
275	-	60	50	40	40	30	25	20	20
280	-	60	50	40	40	30	25	25	20
281	-	60	50	40	40	30	25	25	20

With a profile height of 0 < h ≤ 600 mm
Design tables for installation with fire springs

3.3 Insulation thickness for R90 steel structure

Fire resistance period 90 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	20	20	20	20	20	20	20	20	20
50	25	20	20	20	20	20	20	20	20
55	25	20	20	20	20	20	20	20	20
60	30	25	20	20	20	20	20	20	20
65	30	25	20	20	20	20	20	20	20
70	40	30	25	20	20	20	20	20	20
75	40	30	25	20	20	20	20	20	20
80	40	40	25	20	20	20	20	20	20
85	40	40	30	25	20	20	20	20	20
90	50	40	30	25	20	20	20	20	20
95	50	40	40	30	25	20	20	20	20
100	50	40	40	30	25	20	20	20	20
105	50	50	40	30	25	20	20	20	20
110	60	50	40	40	30	25	20	20	20
115	60	50	40	40	30	25	20	20	20
120	60	50	40	40	30	25	20	20	20
125	60	50	50	40	30	25	25	20	20
130	60	50	50	40	40	30	25	20	20
135	-	60	50	40	40	30	25	20	20
140	-	60	50	40	40	30	25	25	20
145	-	60	50	50	40	30	30	25	20
150	-	60	50	50	40	40	30	25	20
155	-	60	50	50	40	40	30	25	20
160	-	60	60	50	40	40	30	25	25
165	-	-	60	50	40	40	30	25	25
170	-	-	60	50	50	40	30	30	25
175	-	-	60	50	50	40	40	30	25
180	-	-	60	50	50	40	40	30	25
185	-	-	60	50	50	40	40	30	25
190	-	-	60	60	50	40	40	30	30
195	-	-	60	60	50	40	40	30	30
200	-	-	-	60	50	40	40	40	30
205	-	-	-	60	50	50	40	40	30
210	-	-	-	60	50	50	40	40	30
215	-	-	-	60	50	50	40	40	30
220	-	-	-	60	50	50	40	40	30
225	-	-	-	60	50	50	40	40	30
230	-	-	-	60	60	50	40	40	30
235	-	-	-	60	60	50	40	40	40
240	-	-	-	60	60	50	40	40	40
245	-	-	-	60	60	50	50	40	40
250	-	-	-	-	60	50	50	40	40
255	-	-	-	-	60	50	50	40	40
260	-	-	-	-	60	50	50	40	40
265	-	-	-	-	60	50	50	40	40
270	-	-	-	-	60	50	50	40	40
275	-	-	-	-	60	50	50	40	40
280	-	-	-	-	60	50	50	40	40
281	-	-	-	-	60	50	50	40	40

3.4 Insulation thickness for R120 steel structure

Fire resistance period 120 minutes									
Design temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	30	25	20	20	20	20	20	20	20
50	40	30	25	20	20	20	20	20	20
55	40	30	25	20	20	20	20	20	20
60	40	40	30	25	20	20	20	20	20
65	50	40	30	25	20	20	20	20	20
70	50	40	40	30	25	20	20	20	20
75	50	50	40	40	30	25	20	20	20
80	60	50	40	40	30	25	20	20	20
85	60	50	50	40	40	30	25	20	20
90	60	60	50	40	40	30	25	20	20
95	-	60	50	50	40	30	30	25	20
100	-	60	50	50	40	40	30	25	20
105	-	60	60	50	40	40	30	25	25
110	-	-	60	50	50	40	40	30	25
115	-	-	60	50	50	40	40	30	25
120	-	-	60	60	50	40	40	30	30
125	-	-	60	60	50	50	40	40	30
130	-	-	-	60	50	50	40	40	30
135	-	-	-	60	50	50	40	40	30
140	-	-	-	60	60	50	40	40	40
145	-	-	-	60	60	50	50	40	40
150	-	-	-	-	60	50	50	40	40
155	-	-	-	-	60	50	50	40	40
160	-	-	-	-	60	50	50	40	40
165	-	-	-	-	60	60	50	50	40
170	-	-	-	-	60	60	50	50	40
175	-	-	-	-	-	60	50	50	40
180	-	-	-	-	-	60	50	50	40
185	-	-	-	-	-	60	50	50	40
190	-	-	-	-	-	60	60	50	50
195	-	-	-	-	-	60	60	50	50
200	-	-	-	-	-	60	60	50	50
205	-	-	-	-	-	60	60	50	50
210	-	-	-	-	-	-	60	50	50
215	-	-	-	-	-	-	60	50	50
220	-	-	-	-	-	-	60	50	50
225	-	-	-	-	-	-	60	60	50
230	-	-	-	-	-	-	60	60	50
235	-	-	-	-	-	-	60	60	50
240	-	-	-	-	-	-	60	60	50
245	-	-	-	-	-	-	60	60	50
250	-	-	-	-	-	-	60	60	50
255	-	-	-	-	-	-	-	60	50
260	-	-	-	-	-	-	-	60	50
265	-	-	-	-	-	-	-	60	60
270	-	-	-	-	-	-	-	60	60
275	-	-	-	-	-	-	-	60	60
280	-	-	-	-	-	-	-	60	60
281	-	-	-	-	-	-	-	60	60

With a profile height of 0 < h ≤ 600 mm
Design tables for installation with fire springs

3.5 Insulation thickness for R150 steel structure

Fire resistance period 150 minutes									
Design temperature [°C]	**300**	**350**	**400**	**450**	**500**	**550**	**600**	**650**	**700**
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	40	40	30	25	20	20	20	20	20
50	50	40	30	25	20	20	20	20	20
55	50	40	40	30	25	20	20	20	20
60	60	50	40	40	30	25	20	20	20
65	60	50	50	40	40	30	25	20	20
70	60	60	50	40	40	30	25	25	20
75	-	60	50	50	40	40	30	25	20
80	-	60	60	50	50	40	40	30	25
85	-	-	60	50	50	40	40	30	25
90	-	-	60	60	50	50	40	40	30
95	-	-	-	60	50	50	40	40	30
100	-	-	-	60	60	50	40	40	40
105	-	-	-	-	60	50	50	40	40
110	-	-	-	-	60	50	50	40	40
115	-	-	-	-	60	60	50	50	40
120	-	-	-	-	-	60	50	50	40
125	-	-	-	-	-	60	50	50	40
130	-	-	-	-	-	60	60	50	50
135	-	-	-	-	-	60	60	50	50
140	-	-	-	-	-	-	60	50	50
145	-	-	-	-	-	-	60	60	50
150	-	-	-	-	-	-	60	60	50
155	-	-	-	-	-	-	60	60	50
160	-	-	-	-	-	-	-	60	50
165	-	-	-	-	-	-	-	60	60
170	-	-	-	-	-	-	-	60	60
175	-	-	-	-	-	-	-	60	60
180	-	-	-	-	-	-	-	60	60
185	-	-	-	-	-	-	-	-	60
190	-	-	-	-	-	-	-	-	60
195	-	-	-	-	-	-	-	-	60
200	-	-	-	-	-	-	-	-	60
205	-	-	-	-	-	-	-	-	60
210	-	-	-	-	-	-	-	-	60

3.6 Insulation thickness for R180 steel structure

Fire resistance period 180 minutes									
Design temperature [°C]	**300**	**350**	**400**	**450**	**500**	**550**	**600**	**650**	**700**
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	50	50	40	40	30	25	20	20	20
50	60	50	40	40	30	25	20	20	20
55	60	60	50	40	40	30	25	20	20
60	-	60	50	50	40	40	30	25	20
65	-	-	60	50	50	40	40	30	25
70	-	-	60	60	50	40	40	40	30
75	-	-	-	60	50	50	40	40	30
80	-	-	-	60	60	50	50	40	40
85	-	-	-	-	60	50	50	40	40
90	-	-	-	-	60	60	50	50	40
95	-	-	-	-	-	60	60	50	50
100	-	-	-	-	-	60	60	50	50
105	-	-	-	-	-	-	60	50	50
110	-	-	-	-	-	-	60	60	50
115	-	-	-	-	-	-	60	60	50
120	-	-	-	-	-	-	-	60	60
125	-	-	-	-	-	-	-	60	60
130	-	-	-	-	-	-	-	60	60
135	-	-	-	-	-	-	-	-	60
140	-	-	-	-	-	-	-	-	60
145	-	-	-	-	-	-	-	-	60

With a profile height of 0 < h ≤ 600 mm
Design tables for installation with fire springs

3.7 Insulation thickness for R210 steel structure

Fire resistance period 210 minutes									
Design temperature [°C]	**300**	**350**	**400**	**450**	**500**	**550**	**600**	**650**	**700**
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	60	60	50	40	40	30	25	25	20
50	-	60	50	50	40	40	30	25	20
55	-	-	60	50	50	40	40	30	25
60	-	-	-	60	50	50	40	40	30
65	-	-	-	60	60	50	50	40	40
70	-	-	-	-	60	60	50	50	40
75	-	-	-	-	-	60	50	50	40
80	-	-	-	-	-	60	60	50	50
85	-	-	-	-	-	-	60	60	50
90	-	-	-	-	-	-	60	60	50
95	-	-	-	-	-	-	-	60	60
100	-	-	-	-	-	-	-	60	60
105	-	-	-	-	-	-	-	-	60
110	-	-	-	-	-	-	-	-	60

3.8 Insulation thickness for R240 steel structure

Fire resistance period 210 minutes									
Design temperature [°C]	**300**	**350**	**400**	**450**	**500**	**550**	**600**	**650**	**700**
Section factor [m^{-1}]	Thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	-	-	60	50	50	40	40	30	25
50	-	-	60	60	50	50	40	40	30
55	-	-	-	60	60	50	50	40	40
60	-	-	-	-	60	60	50	50	40
65	-	-	-	-	-	60	60	50	50
70	-	-	-	-	-	-	60	60	50
75	-	-	-	-	-	-	-	60	50
80	-	-	-	-	-	-	-	60	60
85	-	-	-	-	-	-	-	-	60
90	-	-	-	-	-	-	-	-	60

4. OPEN AND CLOSED STEEL SECTIONS

With a profile height of 600 < h ≤ 1000 mm
Design tables for installation with welding pins

The tables below are based on assessment no. PHA1111A from The Danish Institute of Fire and Security Technology (DBI) and cover profiles that are exposed on 3 sides to fire with a section factor less than 100 m^{-1}.

4.1 Fire Resistance Period 30 minutes

Design Temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Nominal thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	20	20	20	20	20	20	20	20	20
50	20	20	20	20	20	20	20	20	20
55	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20
65	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20
75	20	20	20	20	20	20	20	20	20
80	20	20	20	20	20	20	20	20	20
85	20	20	20	20	20	20	20	20	20
90	20	20	20	20	20	20	20	20	20
95	20	20	20	20	20	20	20	20	20
100	20	20	20	20	20	20	20	20	20

4.2 Fire Resistance Period 60 minutes

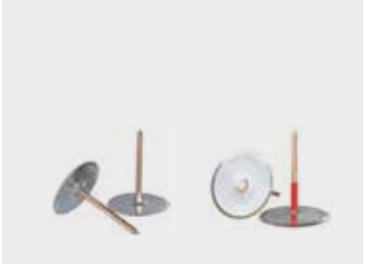
Design Temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Nominal thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	20	20	20	20	20	20	20	20	20
50	20	20	20	20	20	20	20	20	20
55	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20
65	20	20	20	20	20	20	20	20	20
70	25	20	20	20	20	20	20	20	20
75	25	20	20	20	20	20	20	20	20
80	25	20	20	20	20	20	20	20	20
85	30	20	20	20	20	20	20	20	20
90	30	25	20	20	20	20	20	20	20
95	30	25	20	20	20	20	20	20	20
100	40	30	20	20	20	20	20	20	20

4.3 Fire Resistance Period 90 minutes

Design Temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Nominal thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	25	20	20	20	20	20	20	20	20
50	25	20	20	20	20	20	20	20	20
55	30	25	20	20	20	20	20	20	20
60	30	25	20	20	20	20	20	20	20
65	40	30	25	20	20	20	20	20	20
70	40	30	25	20	20	20	20	20	20
75	40	40	30	20	20	20	20	20	20
80	40	40	30	25	20	20	20	20	20
85	50	40	40	30	20	20	20	20	20
90	50	40	40	30	25	20	20	20	20
95	50	50	40	40	30	20	20	20	20
100	50	50	40	40	30	20	20	20	20

43.4 Fire Resistance Period 120 minutes

Design Temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Nominal thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	40	30	25	20	20	20	20	20	20
50	40	30	25	20	20	20	20	20	20
55	40	40	30	25	20	20	20	20	20
60	50	40	40	30	20	20	20	20	20
65	50	50	40	40	25	20	20	20	20
70	50	50	40	40	30	25	20	20	20
75	60	50	50	40	40	30	20	20	20
80	60	50	50	50	40	30	25	20	20
85	60	60	50	50	40	40	30	20	20
90	60	60	60	50	50	40	30	25	20
95	60	60	60	50	50	40	40	30	20
100	-	60	60	60	50	40	40	30	25



With a profile height of 600 < h ≤ 1000 mm
Design tables for installation with welding pins

The tables below are based on assessment no. PHA1111A from The Danish Institute of Fire and Security Technology (DBI) and cover profiles that are exposed on 3 sides to fire and a section factor lower than 100 m^{-1}.

4.5 Fire Resistance Period 150 minutes

Design Temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Nominal thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	50	40	40	30	20	20	20	20	20
50	50	40	40	40	30	20	20	20	20
55	50	50	50	40	40	25	20	20	20
60	60	50	50	50	40	40	25	20	20
65	60	60	50	50	50	40	30	20	20
70	60	60	60	50	50	50	40	30	20
75	60	60	60	60	50	50	40	40	25
80	-	60	60	60	60	50	50	40	30
85	-	-	60	60	60	60	50	40	40
90	-	-	-	60	60	60	50	50	40
95	-	-	-	-	60	60	60	50	40
100	-	-	-	-	60	60	60	50	50

4.6 Fire Resistance Period 180 minutes

Design Temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Nominal thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	50	50	50	50	40	30	20	20	20
50	60	60	50	50	50	40	30	20	20
55	60	60	60	60	50	50	40	30	20
60	60	60	60	60	60	50	50	40	30
65	-	60	60	60	60	60	50	50	40
70	-	-	-	60	60	60	60	50	50
75	-	-	-	-	60	60	60	60	50
80	-	-	-	-	-	60	60	60	60
85	-	-	-	-	-	-	60	60	60
90	-	-	-	-	-	-	-	60	60
95	-	-	-	-	-	-	-	60	60
100	-	-	-	-	-	-	-	60	60

4.7 Fire Resistance Period 210 minutes

Design Temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Nominal thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	60	60	60	60	60	50	50	40	20
50	60	60	60	60	60	60	50	50	30
55	-	-	60	60	60	60	60	60	50
60	-	-	-	-	-	60	60	60	60
65	-	-	-	-	-	-	-	60	60
70	-	-	-	-	-	-	-	-	60
75	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
85	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-
95	-	-	-	-	-	-	-	-	-
100	-	-	-	-	-	-	-	-	-

4.8 Fire Resistance Period 240 minutes

Design Temperature [°C]	300	350	400	450	500	550	600	650	700
Section factor [m^{-1}]	Nominal thickness in mm of fire protection material to maintain steel temperature below design temperature								
47	-	-	60	60	60	60	60	60	60
50	-	-	-	-	-	-	-	-	60
55	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-
65	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	-	-
75	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
85	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-
95	-	-	-	-	-	-	-	-	-
100	-	-	-	-	-	-	-	-	-

5. INSTALLATION INSTRUCTIONS

5.1. Beams & columns, installation with welding pin

PAROC FPS 17 is fitted using PAROC Welding Pins, a 2.7 mm copper coated steel pin with a 30 mm galvanized washer (or similar). The length of the pins depends on the thickness of the mineral wool slabs and ranges from 20–60 mm.

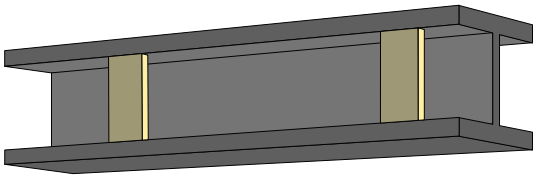
For some slab joints, where two layers of insulation are needed, PAROC Fire Springs should be used, where the chosen length shall be at least twice the thickness of the mineral wool slab.

The fire protection system is intended for use as a fire protection kit for structural steel elements.

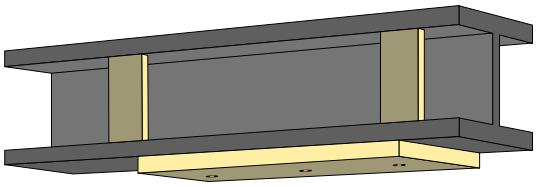
The fire protection system is intended for indoor installation under normal indoor temperatures and normal humidity conditions. Any damage can be repaired by simply replacing the damaged slabs.

Beams or columns exposed to fire on 4 sides, fitted as a box encasing the profile

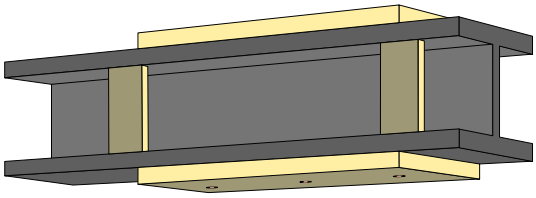
a. Install the supports behind slab joints. Use boards of the same thickness as those used for the fire protection. Make sure to cut the supporting strips 2–3 mm longer than the distance between flanges to obtain a tight fit.



b. Fit the protective slab on the lower side of the beam, or for a column, on one flange side of the profile. Fasten the slab with PAROC Welding Pins. If the flange is less than 180 mm wide, one row of pins is needed (4 pins/slab). For flanges wider than 180 mm, two rows of pins are required (8 pins/slab). The pins should be fitted at a maximum separation of 367 mm and 50 mm from the slab joint.



c. Install the protective slab on the other flange as described in previous step.

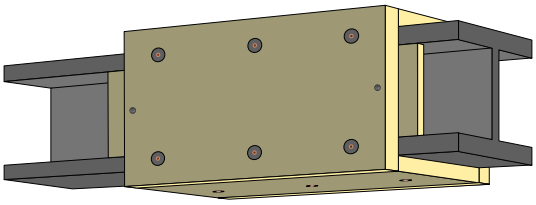


Protective coatings

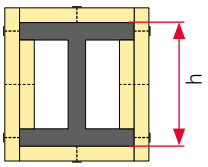
Protective coatings are the most widespread solution for protecting steel against corrosion. Anti-corrosion primer is generally applied immediately after the steel is manufactured to prevent rusting during storage and transportation, and before further processing (cutting, welding, pinning, drilling, etc.). The recommended anti-corrosion primers are often too thick (~50 µm) for welding and need to be removed before welding or pinning. Removal is usually done by grinding.

It is possible to find new primer products on the market that claim to provide good corrosion protection and to be weldable. These products often need to be applied in thin layers to be weldable (about 25 microns thick coating to enable an arc to strike through and reduce the chances of porosity due to the zinc content). Where primers are thin enough (~25 µm) to allow welding, their anti-corrosion properties become so limited that they do not reduce the corrosion. Which is why they are not often used.

d. The protection slabs on the sides are fastened with welding pins on the upper and lower flange. Pins should be fitted at a maximum separation of 367 mm and maximum 50 mm from the slab joint. The protection slabs have to be fixed to the supporting boards in the web by PAROC Fire Springs. The length of the PAROC Fire Spring shall be at least twice the insulation thickness. The number of springs depends on the profile height.



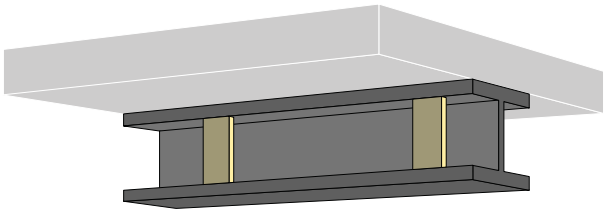
h < 400 mm – no fire springs are needed
400 < h ≤ 600 mm – 1 fire spring on each side of the joint



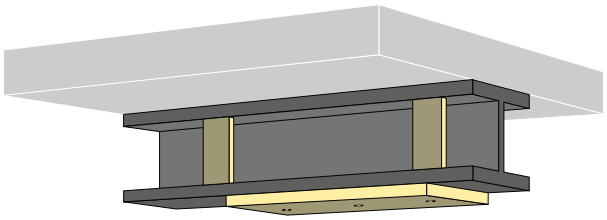
For rectangular beams or columns, the installation shall be done as described above, but no supporting boards or fire springs are needed. The number of PAROC Welding Pins needed depends on the profile sides. If the side of the profile is less than 180 mm, one row of pins is needed (4 pins/slab). Sides wider than 180 mm require two rows of welding pins (8 pins/ board). The pins should be fitted at a maximum separation of 367 mm and 50 mm from the board joint.

Beams or columns exposed to fire on 3 sides, fitted as a box encasing the profile

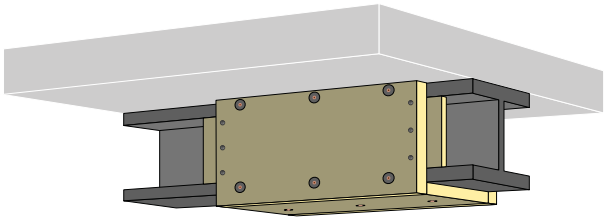
a. Install the supports behind slab joints. Use boards of the same thickness as used for the fire protection. Make sure to cut the supporting boards 2–3 mm longer than the distance between flanges to obtain a tight fit.



b. Mount the protective slab on the exposed side of the beam or column. Fasten the board with PAROC Welding Pins. If the flange is less than 180 mm wide, one row of pins is needed (4 pins/slab). For flanges wider than 180 mm, two rows of pins are required (8 pins/slab). The pins should be fitted at a maximum separation of 367 mm and 50 mm from the board joint.

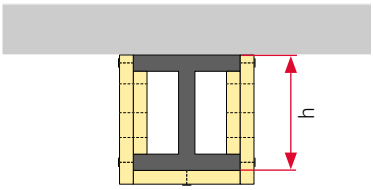


c. The protective slabs on the sides are fastened using welding pins on the upper and lower flange. Pins should be fitted at a maximum separation of 367 mm and maximum 50 mm from the slab joint.
The protective slabs shall be fixed to the supporting boards in the web using PAROC Fire Springs. The length of the PAROC Fire Springs shall be at least twice the insulation thickness. The number of springs depends on the profile height.



h < 400 mm – no fire springs are needed
400 < h ≤ 600 mm – 1 fire spring on each side of the joint
600 < h ≤ 1000 mm – max separation 300 mm

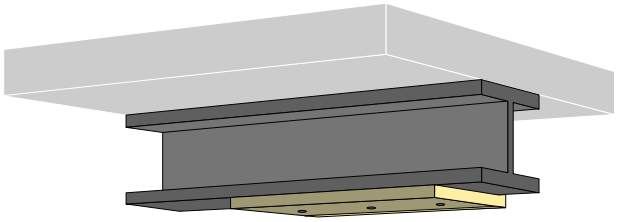
Standard FPS 17 slab, with dimensions 600x1200 mm, can be used for the fire protection of higher beams by fitting it vertically. Welding pins are fitted on board's short edge at max separation 250 mm and max 50 mm from the slab joint.



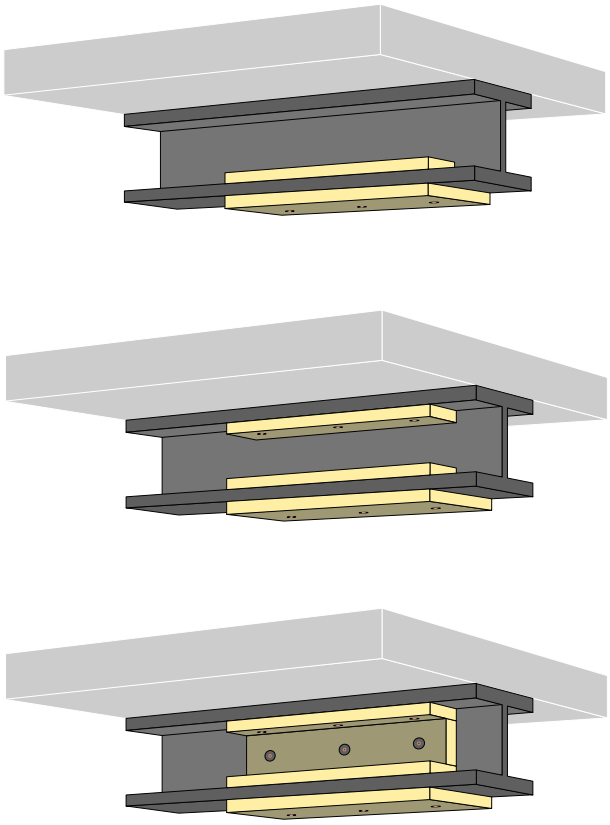
For rectangular beams or columns, the installation has to be done as described above, but no supporting boards or fire springs are needed. The number of PAROC Welding Pins needed depends on the profile sides. If the side of the profile is less than 180 mm, one row of pins is needed (4 pins/slab). Sides wider than 180 mm require two rows of welding pins (8 pins/slab). The pins should be fitted at a maximum separation of 367 mm and 50 mm from the slab joint.

Beams or columns exposed to fire on 3 and 4 sides, fitted with insulation following the profile

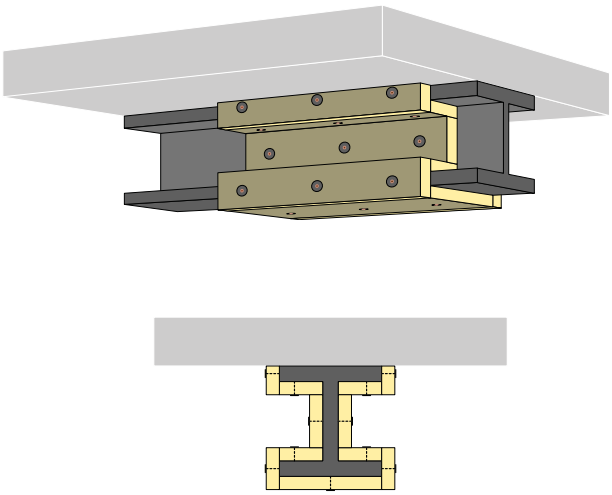
a. Fit the protection slab on the exposed side of the beam or column. Fasten the board with PAROC Welding Pins. If the flange is less than 180 mm wide, one row of pins is needed (4 pins/slab). For flanges wider than 180 mm, two rows of pins are required (8 pins/slab). The pins should be mounted at a maximum separation of 367 mm and 50 mm from the board joint.



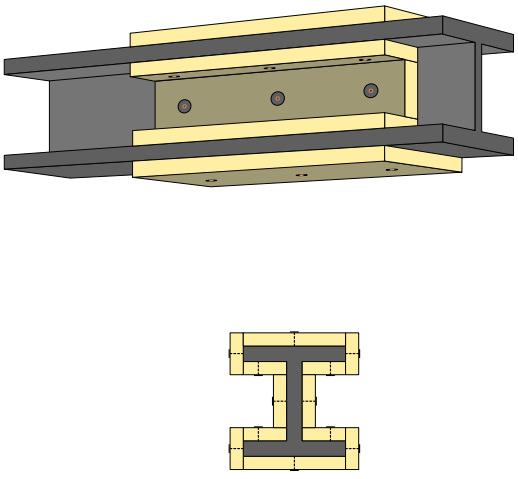
b. Fit the insulation inside the web of the beam, using the same distances between PAROC Welding pins described above.



c. Finally, fit the slabs covering the edge of the flanges. Use PAROC Welding pins, maximum c/c 367 mm, and maximum 50 mm from the slab joints.



d. For profiles exposed on 4 sides, install the protective slab on the other flange as described in previous step.



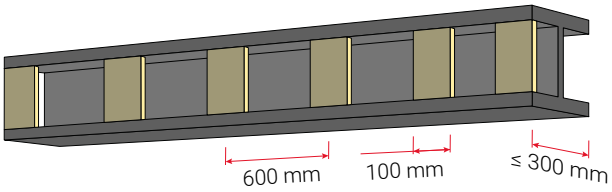
5.2 Beams & columns, fitted using fire springs

Fitting PAROC FPS 17 fire protection with PAROC Fire Springs is an ideal solution when welding is impossible or difficult, e.g., when the steel you want to protect is coated with an anti-corrosion paint.

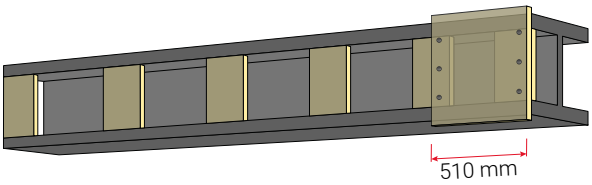
The length of the PAROC Fire Spring depends on the thickness of the fire protection slabs and ranges from 20–60 mm. Instructions how to choose correct length for fire spring can be found on installation details below.

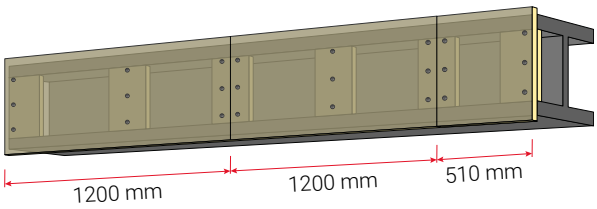
The fire protection system is intended for use as a fire protection kit for structural steel elements. The fire protection system is intended for indoor installation under normal indoor temperatures and normal humidity conditions. Any damage to the insulation can be repaired by simply replacing the damaged slabs.

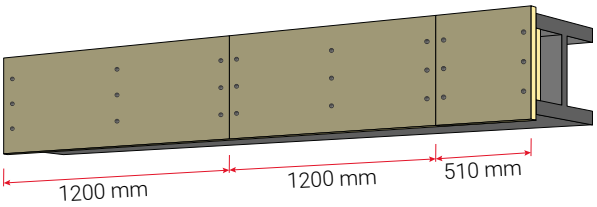
Beams or columns exposed to fire on 4 sides, fitted as a box encasing the profile

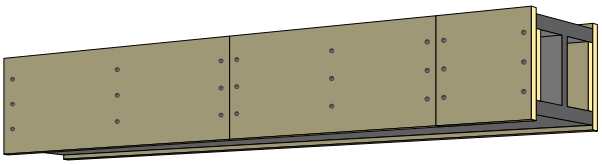


a. Install the supports between the flanges, they shall be positioned at slab joints and at the center of each slab, max 600 mm separation. Thickness of supporting boards should be 60 mm. Make sure to cut the supporting boards 2-3 mm longer than the distance between flanges to obtain a tight fit.

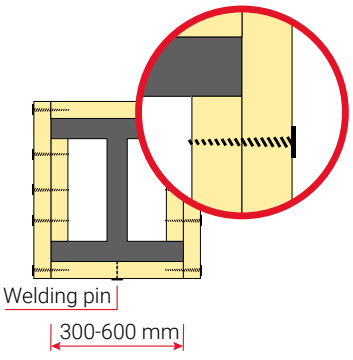




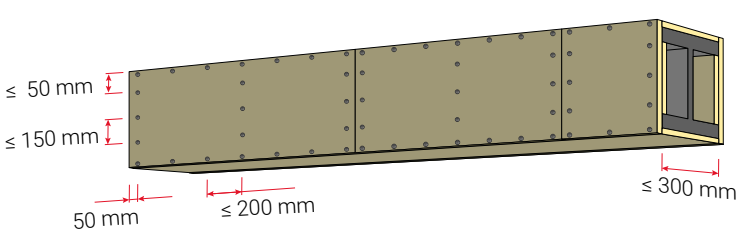


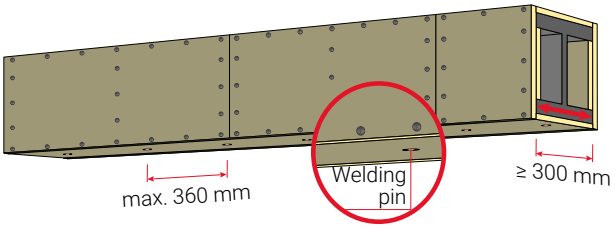


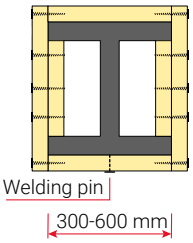
b. Fit the slabs on the side of the beam or column, by fastening them to the supports with minimum 3 fire springs. The length of the fire spring should be at least insulation thickness + 60 mm (support board thickness). The height of the slabs should be the profile height + 2 x insulation thickness. Repeat the procedure on the other side of the profile.

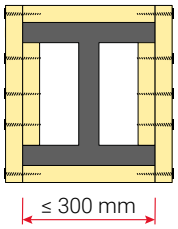


Beams or columns exposed to fire on 4 sides, fitted as a box encasing the profile



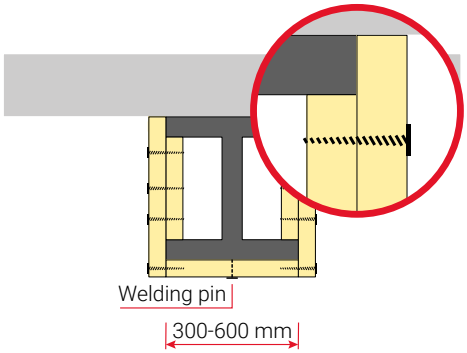


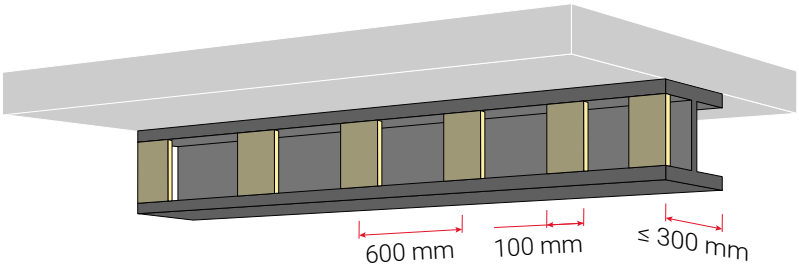




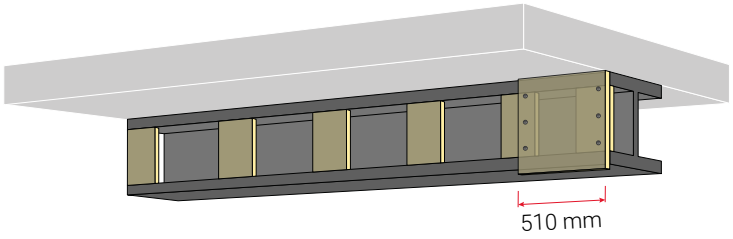
c. Cut the slabs for the two flange sides, make sure that they are a few millimeters wider than the flange to ensure a sealed installation. Fit the slabs on the lower side of the beam, or for a column, on one flange side of the profile. Fasten the slabs with PAROC Fire Springs through the side slab into the edge of the bottom slab. Length of the fire spring should be at least 2 x insulation thickness. For a beam where the flange is wider than 300 mm, one row of welding pins is needed (4 pins/slab) on the lower flange. No welding pins are needed on the top flange and if the flange is less than 300 mm.

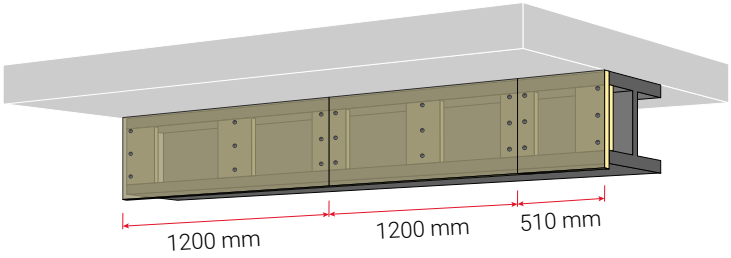
Beams or columns with exposed to fire on 3 sides, fitted as a box encasing the profile

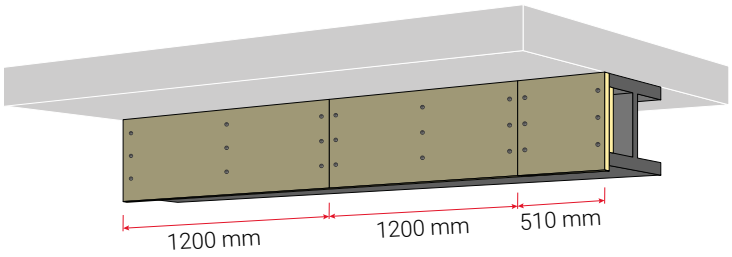


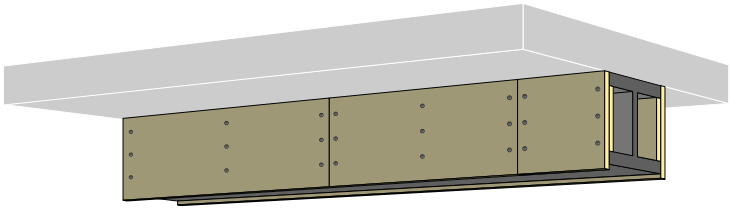


a. Fit the supports between the flanges, they have to be positioned at slab joints and at the center of each slab, max 600 mm separation. Thickness of supporting boards should be 60 mm. Make sure to cut the supporting boards 2–3 mm longer than the distance between the flanges to obtain a tight fit.



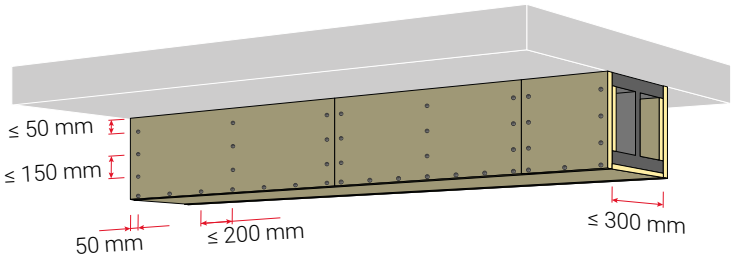


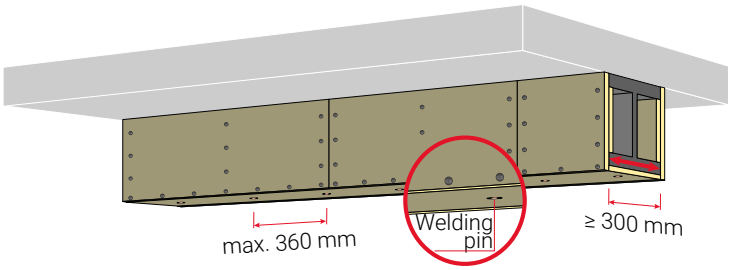


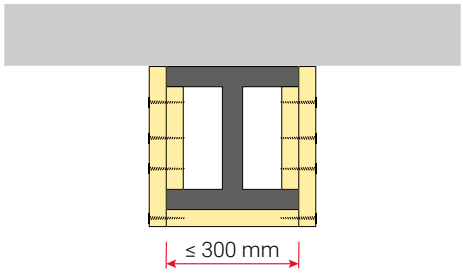


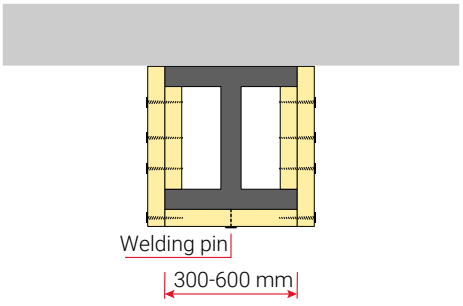
b. Fit the slabs on the side of the beam or column, by fastening them to the supports with minimum 3 fire springs. The length of the fire spring should be at least insulation thickness + 60 mm (support board thickness). The height of the slabs should be the profile height + 1 x insulation thickness.

Beams or columns with exposed to fire on 3 sides, fitted as a box encasing the profile









c. Cut the slabs for the bottom flange, make sure that the slabs are a few millimeters wider than the flange to ensure a sealed installation. Fit the slabs on the lower side of the beam, or for a column, on the flange side of the profile. Fasten the slab with PAROC Fire Springs through the side slabs into the edge of the bottom slab. Length of the fire spring should be at least 2 x insulation thickness. For a beam where the flange is wider than 300 mm, one row of welding pins is needed (4 pins/slab) on the lower flange. No welding pins are needed, if the flange is less than 300 mm.

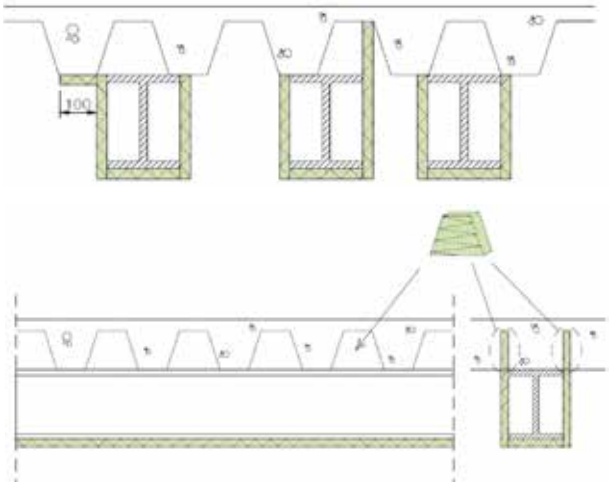
5.3. Connection details

When the fire protected steel beam is installed under a composite steel deck, the following construction details must be taken into consideration. Please note that the fire protection of the load-bearing trapezoidal steel sheet and the fire protection of the load-bearing beam must always be considered separately.

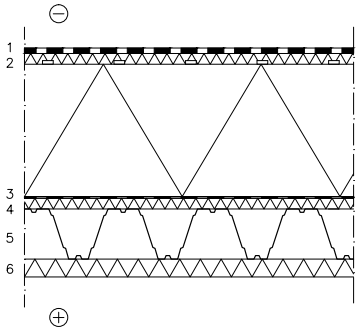
The fire protection slab has to be installed tightly against the deck. No gaps are allowed.

Where there is a gap in the corrugation of the adjoining corrugated deck, fire insulation with a width of 100 mm has to be fixed adjacent to the fire insulation board on the profile.

If the profile is installed across the corrugated steel deck, precut pieces of the same insulation are pressed into the corrugation before installing the fire insulation on the vertical side of the profile. Pieces have to be glued to the metal sheet with fire resistant sealant or similar.



6. ROOF STRUCTURES



Steel trapezoid roofs are widely used for various types of building. These roofs usually consist of steel beams, steel trapezoid profile, vapor barrier, thermal insulation and roof membrane. Since each component in this structure has very different fire behavior, it is best to test the whole system to see how it behaves in a fire.

The load-bearing capacity of trapezoid steel without fire protection is approximately 15–30 minutes, depending on the structure. The steel sheet bends, but the load-bearing capacity still remains for a while. When no insulation is used on top of the load-bearing steel sheet, the heat goes through the metal and dissipates upwards, and the temperature of the steel rises slower. When insulation is fitted on top of the steel sheet, the temperature of the metal rises very quickly. This is why you need to take into consideration the amount of insulation above the corrugated steel sheet when determining the thickness of the fire protection below the corrugated steel construction.

As a supporting shell, steel trapezoid profile must usually be protected from fire to prevent premature failure of the entire roof structure.

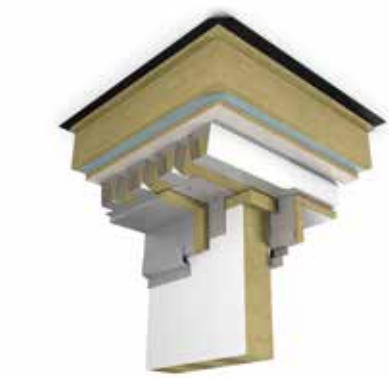
Design conditions:

- Max distance of load-bearing beams underneath is 4 m
- Trapezoidal steel sheet is fitted to the load-bearing structure
- Applied load in the test was 0.9 kN/m^2
- Increasing the thickness of the thermal insulation is permitted
- The slope of the roof is in range of 0–15°

Note: The failure limit in fire test for deflection is 312.5 mm/ 44 mm/min.

Fire protection of trapezoid steel sheet

Because the insulation above the metal sheet affects the results of fire resistance tests, it is not possible to obtain a classification for the fire protection product beneath the structure alone. The test has to be done for the entire construction. Paroc roof solution has been tested according to EN 1365-2:2014 and is classified in according with EN 13501-1:2007 + A1:2009.



FIRE RESISTANCE CLASS RE 60 / REI 60

PVC or bitumen membrane

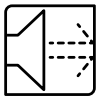
1. **30 mm PAROC ROB 100**
   200 mm PAROC ROL 30
   fixed to metal sheet using SFS Intect ISO-TAK RP45 BS-S-4.8 or simila
2. Vapor barrier (for example 4 mm thick bitumen membrane)
3. **30 mm PAROC Robster**
4. Trapezoidal steel sheet (T130M-75L-930 steel thickness 0.7 mm joined with self-drilling screws, SD3-T15 4.8x19 at 300 mm spacing)
5. **50 mm PAROC FPS 17** (fixed to steel sheet using self-drilling screws Intect BS 4.8x70 with washers PAROC XFW 003, 6 pc/slab). Fire protection can also be fitted using welding pins, 8 pcs/slab).

The distance of the fastener from the edge of the fire protection slab shall be ≤ 100 mm. The exact location of the fastener should be evaluated on a case-by-case basis, according to the trapezoid steel sheet used. The fasteners should be fitted as far as possible from each other.

Due to the cavities in steel sheets in the areas at partition walls, penetrations and roof ends, corrugations have to be tightly sealed separately on both sides of the joint by using precut pieces of PAROC FPS 17 or PAROC ROX 2. The pieces have to be glued to the metal sheet with fire seal or similar.

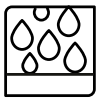
DURABLE

REUSABLE



SOUND REDUCING

FIRE PROOF



MOISTURE PROOF

SAFE

ENERGY EFFICIENT

PAROC® stands for energy-efficient and fire safe insulation solutions of stone wool for new and renovated buildings, marine and offshore, acoustics and other industrial applications. Behind the products, there is an 80-year history of stone wool production, know-how backed by technical insulation expertise and innovation.

Building Insulation offers a wide range of products and solutions for all traditional building insulation. The building insulation products are primarily used for the thermal, fire and sound insulation of exterior walls, roofs, floors and basements, mezzanines and partitions.

Technical Insulation offers thermal, fire and sound insulation in HVAC systems, industrial processes and pipework, industrial equipment as well as shipbuilding and offshore industry etc.

For more information, please visit ***www.paroc.com***

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Replaces November 2019
2084BIEN1022

OWENS CORNING PAROC