PAROC®
Better built environment

FIRE PROTECTION GUIDE STEEL
Glue free system

DETERMINE THE NEEDED FIRE RESISTANCE PERIOD

The fire resistance requirement for a building is defined in terms of fire resistance period and stated in terms of minutes (15, 30, 45, 60, 75, 90 or 120 minutes). This information is usually given in local building regulations and it depends on the height, occupants and type of the building. In practice it means the building frame has to maintain its load bearing capacity during the fire until everybody has left the burning building. It is the responsibility of the design engineer, using design codes such as ENV1993-1-2, to specify the appropriate 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 which demonstrates development of real fire. The temperature in a standard fire rises rather 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 raise on the cold side of the structural element, usually max.140 °C) (I)
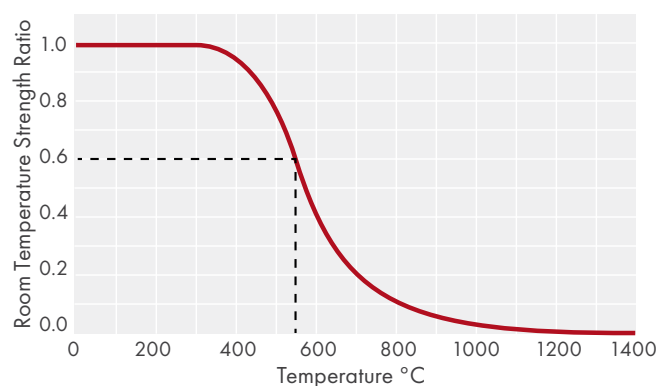
In some building constructions all of these are needed but for the steel frames only load bearing capacity is required.

DETERMINE CRITICAL TEMPERATURE AND THE SECTION FACTOR OF THE STEEL

All materials lose their strength as they get hot.
- A fully loaded steel beam exposed on four sides, fails at 550 °C, regardless of steel grade.
- Fully loaded beam exposed on three sides, fails at 620 °C. ⇒ Temperature 450 °C is commonly used as a rather safe limit value.

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

A steel section with a large surface area (A) (m²/m) will receive more heat than one with a smaller surface area. Also, the greater the volume (V) (m³/m) of the section, the greater is the heat sink. It follows therefore, that a small thick section will be slower to increase in temperature than a large thin one.

Large A
Small V
⇒ fast heating

Small A
Large V
⇒ slow heating

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

The design of fire protection is therefore based on this limiting temperature for elements exposed to fire on four sides. The aim is to keep steel temperature below its critical temperature.

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

Example of calculating section factor Am/V

- Surface area (Am) of one metre long beam is 1,38 m²
- Volume (V) of one metre long beam is 0,0068 m³

A / V = 1,38 / 0,0068 = 203 m⁻¹

Section factors vary generally from 25 m⁻¹ for very large sections to over 300 m⁻¹ for small, slender sections.

100 mm

500 mm

10 mm
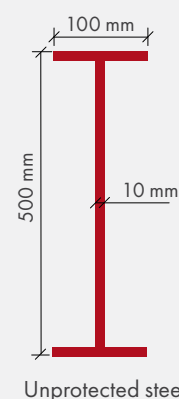
Unprotected steel

SHADOW EFFECT

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

- I-profiles: $k_{shadow} = 0,9 \, [A_m/V]_{box} / [A_m/V]$
- $\square$-profiles: $k_{shadow} = 1$
- Insulated profiles = 1 (all)

Shadow effect   No shadow effect
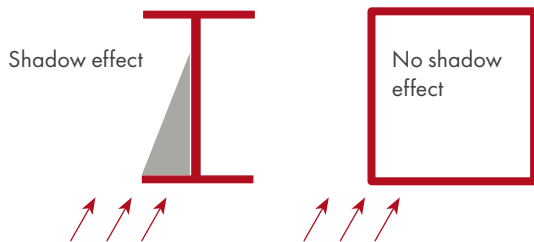
Whilst the section factor can be calculated it is more usual to refer to different steel manufacturers' profile information where this value is given.

DETERMINE PROTECTION METHOD

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

Profile   Box   Solid

Sprayed materials would normally be applied to follow the profile of the section. Special insulating concretes can be used to form solid protection. Board materials would normally be 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 also insulation conducts heat. In case of protected members the section factor A_p/V is multiplied by a factor, 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 fire protection insulation needed depends on
- **Duration of fire resistance specified in national regulations (R30, R60, R90, R120…)**
- **Critical temperature and the section factor of the steel**
  –> Perimeter of steel section exposed to fire (A)
  –> Shape and size of steel section (total volume, V)
- **Type of protection used**

PAROC FIRE SAFE SYSTEM – PAROC FPS 17

Design tools for prediction of stone wool fire protection board thickness have been made for 30–120 minutes endurance time in a Standard Fire Exposure (R30–R120) for open and closed (I/H and CHS/RHS sections) steel sections.

Based on graphical or tabulated design values PAROC FPS 17 board thickness can be chosen as a function of
- fire endurance time,
- section factor A/V for the member and
- Critical steel temperature ranging from 350–700°C
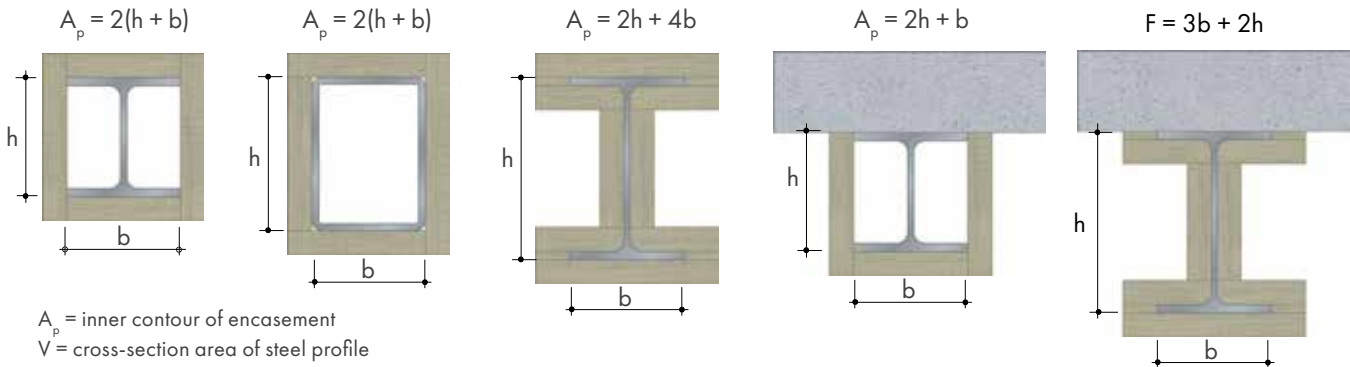 CHS = circular hollow section
  RHS = retangular hollow section

In case of "box" protection, the surface area is taken as the sum of the inside dimensions of the smallest possible rectangular or square encasement except in the case of circular hollow sections, where the air space created by boxing a circular section improves the insulation, allowing reduced material thicknesses.

A_P/V – SECTION FACTOR FOR PROTECTED MEMBERS

Section factor for insulated steel members:

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

When I profiles have a greater height than 450 mm the insulation shall be installed following the profile.

$A_p = 2(h + b)$ $A_p = 2(h + b)$ $A_p = 2h + 4b$ $A_p = 2h + b$ $F = 3b + 2h$

A_p = inner contour of encasement
V = cross-section area of steel profile

Calculation example

Steel beam, encased on three sides
- Serial size: 406 mm x 178mm x 54 kg/m
- Actual size: 402,6 mm x 177,6 mm
- V = 0,00684 m³

A = 2h + b –> 402,6 + 402,6 + 177,6 = 982,8 mm × 1000 mm = 0,9828 m²

$$A/V = 0,9828 \text{ m}^2/0,00684 \text{ m}^3 = 143,7 \text{ m}^{-1} = \textbf{144 m}^{-1}$$

or

If the mass per metre is known then the A/V value can be calculated:

$$A/V = (\rho \times A)/W = 7850 \text{ kg/m}^3 \times 0,9828 \text{ m}^2/54 \text{ kg/m} = \textbf{143 m}^{-1}$$

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

(Nominal density of steel is 7850 kg/m³, 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 data for the steel profile from the steel supplier. For example section factor for four sides exposed HE 140 B profile is 130 m^{-1}

2 In the following figures you can find the fire class and the needed thickness of insulation. Choose the table based on critical temperature, check the needed fire resistance time and read 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 60 minutes, you need 20 mm PAROC FPS 17 fire protection for the section factor 130 m^{-1}

HEA-profile			HEB-profile			HEM-profile	
a	b		c	d		e	f
	a A_p/V (m^{-1})	b A/V (m^{-1})		c A_p/V (m^{-1})	d A_p/V (m^{-1})		e A_p/V (m^{-1})	f 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			

INSULATION THICKNESS FOR PAROC FPS 17 (mm)
CRITICAL STEEL TEMPERATURE 450°C

A_p/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	25	40	40	50
60	20	20	20	30	40	50	60
70	20	20	20	40	50	60	
80	20	20	25	40	50		
90	20	20	25	40	60		
100	20	20	30	50			
110	20	20	40	50			
120	20	20	40	60			
130	20	20	40	60			
140	20	20	40	60			
150	20	20	50				
160	20	25	50				
170	20	25	50				
180	20	25	50				
190	20	25	50				
200	20	25	50				
210	20	30	60				
220	20	30	60				
230	20	30	60				
240	20	30	60				
250	20	30	60				

ETA approved !

Given insulation thicknesses on the tables are based on designed program of fire tests on both loaded and unloaded specimens and a mathematical procedure applied to the results of the tests. 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 13501-2 and ENV 13381-4:2002 in Sintef NBL, Norway. This system has European Technical Approval issued by VTT Expert Services.

OPEN AND CLOSED STEEL SECTIONS

CRITICAL TEMPERATURE 350°C Multiple R 0,998273 $a_0 = 0$ R^2 0,99655 $K_{MOD} = 0,97$

A_p/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	40	50	60	
60	20	20	25	40	50		
70	20	20	30	50	60		
80	20	20	40	50			
90	20	20	40	60			
100	20	20	40	60			
110	20	25	50				
120	20	25	50				
130	20	30	50				
140	20	30	50				
150	20	30	60				
160	20	40	60				
170	20	40	60				
180	20	40	60				
190	20	40					
200	20	40					
210	20	40					
220	20	40					
230	20	40					
240	20	40					
250	20	40					

CRITICAL TEMPERATURE 400°C Multiple R 0,998041 $a_0 = 0$ R^2 0,996085 $K_{MOD} = 0,97$

A_p/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	25	40	50	60
60	20	20	20	40	50	60	
70	20	20	25	40	50		
80	20	20	30	50	60		
90	20	20	30	50			
100	20	20	40	60			
110	20	25	40	60			
120	20	25	40	60			
130	20	25	40				
140	20	25	50				
150	20	25	50				
160	20	25	50				
170	20	30	50				
180	20	30	60				
190	20	30	60				
200	20	30	60				
210	20	40	60				
220	20	40	60				
230	20	40	60				
240	20	40					
250	20	40					

CRITICAL TEMPERATURE 450°C   Multiple R 0,997913 $\alpha_0 = 0$ R^2 0,99583 $K_{MOD} = 0,97$

A_P/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	25	40	40	50
60	20	20	20	30	40	50	60
70	20	20	20	40	50	60	
80	20	20	25	40	50		
90	20	20	25	40	60		
100	20	20	30	50			
110	20	20	40	50			
120	20	20	40	60			
130	20	20	40	60			
140	20	20	40	60			
150	20	20	50				
160	20	25	50				
170	20	25	50				
180	20	25	50				
190	20	25	50				
200	20	25	50				
210	20	30	60				
220	20	30	60				
230	20	30	60				
240	20	30	60				
250	20	30	60				

CRITICAL TEMPERATURE 500°C   Multiple R 0,997794 $\alpha_0 = 0$ R^2 0,995592 $K_{MOD} = 0,97$

A_P/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	20	30	40	50
60	20	20	20	25	40	50	60
70	20	20	20	30	40	50	
80	20	20	20	30	50	60	
90	20	20	25	40	50		
100	20	20	25	40	60		
110	20	20	30	50	60		
120	20	20	30	50			
130	20	20	30	50			
140	20	20	40	60			
150	20	20	40	60			
160	20	20	40	60			
170	20	20	40	60			
180	20	20	40				
190	20	20	50				
200	20	20	50				
210	20	25	50				
220	20	25	50				
230	20	25	50				
240	20	25	50				
250	20	25	50				

CRITICAL TEMPERATURE 550°C   Multiple R 0,997696 $\alpha_0 = 0$ R^2 0,995398 $K_{MOD} = 0,97$

A_P/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	20	25	30	40
60	20	20	20	20	30	40	50
70	20	20	20	25	40	50	60
80	20	20	20	30	40	50	
90	20	20	20	30	50	60	
100	20	20	20	40	50		
110	20	20	25	40	60		
120	20	20	25	40	60		
130	20	20	30	50	60		
140	20	20	30	50			
150	20	20	30	50			
160	20	20	40	50			
170	20	20	40	60			
180	20	20	40	60			
190	20	20	40	60			
200	20	20	40	60			
210	20	20	40				
220	20	20	50				
230	20	20	50				
240	20	20	50				
250	20	20	50				

CRITICAL TEMPERATURE 600°C   Multiple R 0,998351 $\alpha_0 = 0$ R^2 0,996705 $K_{MOD} = 0,97$

A_P/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	20	20	25	40
60	20	20	20	20	25	40	40
70	20	20	20	20	30	40	50
80	20	20	20	25	40	50	60
90	20	20	20	25	40	50	60
100	20	20	20	30	40	60	
110	20	20	20	40	50	60	
120	20	20	20	40	50		
130	20	20	25	40	60		
140	20	20	25	40	60		
150	20	20	25	50	60		
160	20	20	30	50			
170	20	20	30	50			
180	20	20	30	50			
190	20	20	40	60			
200	20	20	40	60			
210	20	20	40	60			
220	20	20	40	60			
230	20	20	40				
240	20	20	40				
250	20	20	40				

**CRITICAL TEMPERATURE 650°C**   Multiple R 0,998572 $\alpha_0 = 0$ R^2 0,997146 $K_{MOD} = 0,97$

A_P/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	20	20	25	30
60	20	20	20	20	20	30	40
70	20	20	20	20	25	40	40
80	20	20	20	20	30	40	50
90	20	20	20	25	30	40	50
100	20	20	20	25	40	50	60
110	20	20	20	30	40	50	
120	20	20	20	30	50	60	
130	20	20	20	40	50	60	
140	20	20	20	40	50		
150	20	20	20	40	60		
160	20	20	25	40	60		
170	20	20	25	50	60		
180	20	20	25	50			
190	20	20	30	50			
200	20	20	30	50			
210	20	20	30	60			
220	20	20	30	60			
230	20	20	40	60			
240	20	20	40	60			
250	20	20	40	60			

CRITICAL TEMPERATURE 700°C   Multiple R 0,998565 $\alpha_0 = 0$ R^2 0,997132 $K_{MOD} = 0,97$

A_P/V	Fire resistant time minutes						
	30	60	90	120	150	180	210
50	20	20	20	20	20	20	25
60	20	20	20	20	20	25	30
70	20	20	20	20	20	30	40
80	20	20	20	20	25	30	40
90	20	20	20	20	30	40	50
100	20	20	20	20	30	40	50
110	20	20	20	25	40	50	60
120	20	20	20	25	40	50	60
130	20	20	20	25	40	50	
140	20	20	20	30	50	60	
150	20	20	20	30	50	60	
160	20	20	20	40	50		
170	20	20	20	40	60		
180	20	20	20	40	60		
190	20	20	20	40	60		
200	20	20	20	50			
210	20	20	25	50			
220	20	20	25	50			
230	20	20	25	50			
240	20	20	25	60			
250	20	20	30	60			

INSTALLATION

1 The insulation is fastened by welding steel pins (Ø 2,8 mm) with washers (Ø 30 mm).

2 Pins on beams are fastened maximum 50 mm from the edges.

3 Pins on columns are fastened maximum 110 mm from the edges.

4 The maximum distance between fasteners on columns is 400 mm.

5 For beams the maximum distance between fasteners is 300 mm.

6 When installing insulation on H or I profiles with distances between flanges more than 200 mm a supporting board is placed behind board joints.

7 The supporting board shall be 100 mm in width and of the same thickness as the main insulation.

8 When the distance between flanges is more than 300 mm, a supporting board is secured with another board installed perpendicular to the supporting board, made from the main insulation thickness.

9 Both boards are cut oversized so they fit tight. No glue or glue or equivalent is needed.

10 All edges of the profile are fully covered by the boards.

11 At installation on beams the boards on the sides shall cover the bottom layer boards and not vice versa.

12 No openings in fire protection are allowed.
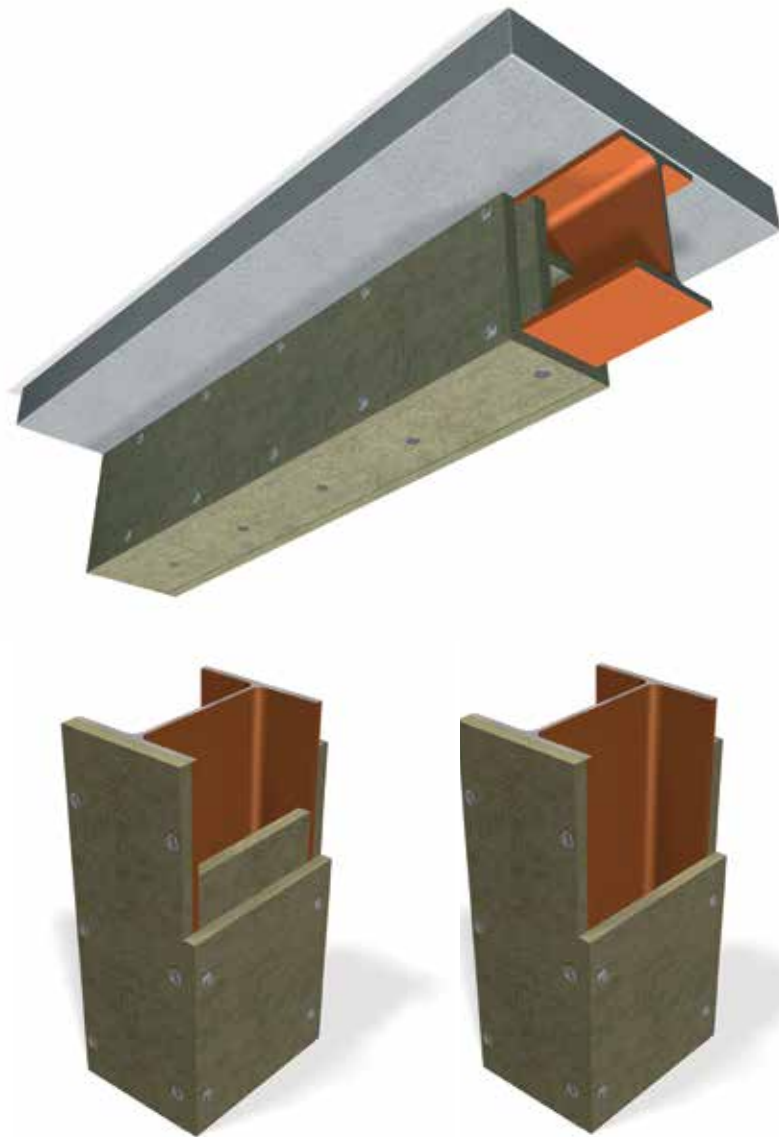
PAROC XPS 001 Fire spring

Steel pin

○ Fire protection made by inorganic stone wool is very durable. Maintenance is only needed if there will be some impact damage. Damage is very easy to repair just by changing the current part of the insulation.

○ Paroc FireSAFE system shall be used in indoor spaces with normal indoor temperature and moisture conditions.
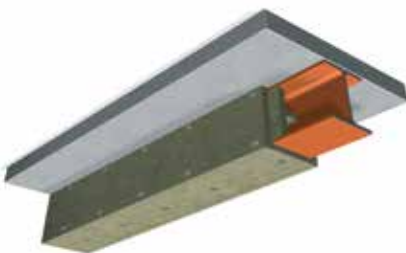
INSTALLATION OF PAROC® FIRESAFE SYSTEM

GENERAL:
MOUNTING I-PROFILES >200 MM

WELDING

1 Cut the installation pieces with a width of 100 mm and a length suitable to the profile with 2–3 mm extra length. Use always the same thickness of slab as used for the current profile.

2 Press the pieces of insulation between the flanges as a backing behind any joint.

When the beam or column has a height over 300 mm the piece of insulation is completed with perpendicular placed piece.

The insulation is fixed by using steel pin/washers. The pin is an Ø 2,8 mm with fixed washer at Ø 30,0 mm.

The pin used is chosen 2–3 mm greater than the insulation thickness.

The boards should form a solid corner for the steel profile. No steel shall be visible.

Follow the instructions at the welding equipment to install the pins properly.

Ensure that the pins are properly fastened. The pins should be possible to bend aside (without insulation) and stay fastened.

The welding is done by Capacitor Discharge (CD) equipment – or equal.

See instructions on page 7.

RHS-PROFILES
Insulation should be fixed to the top of RHS profiles by butt welding.

The steel pins are fixed at intervals of less than 400 mm and less than 110 mm from joints in the insulation.

ALTERNATIVE INSTALLATION METHOD

The ETA approval allows also the steel structure fire protection to be fixed with screws.

SCREW FIXING

The insulation is fixed using special screws, PAROC® XFS 001 Fire Spring. The first stage of installation is to push 100 mm wide pieces of PAROC® FPS 17 between the flanges of the steel profile, with a maximum centre-to centre spacing of 600 mm.

The thickness of the supporting board must be at least 40 mm. If the height of the beam is greater than 400 mm a piece of board must be placed perpendicular to provide additional support. If the width of profile flange is greater than 300 mm then 2,8 mm pins must be welded to the centre line of the flange at 300 mm intervals.

Cut the insulation so that it is equal to the height of the beam, plus the thickness of the flange insulation. Fix at least two fire spring at intervals of 200 mm or less. The spacing between the springs is shown in the figure. It is recommended that the fire spring length is twice the insulation thickness.
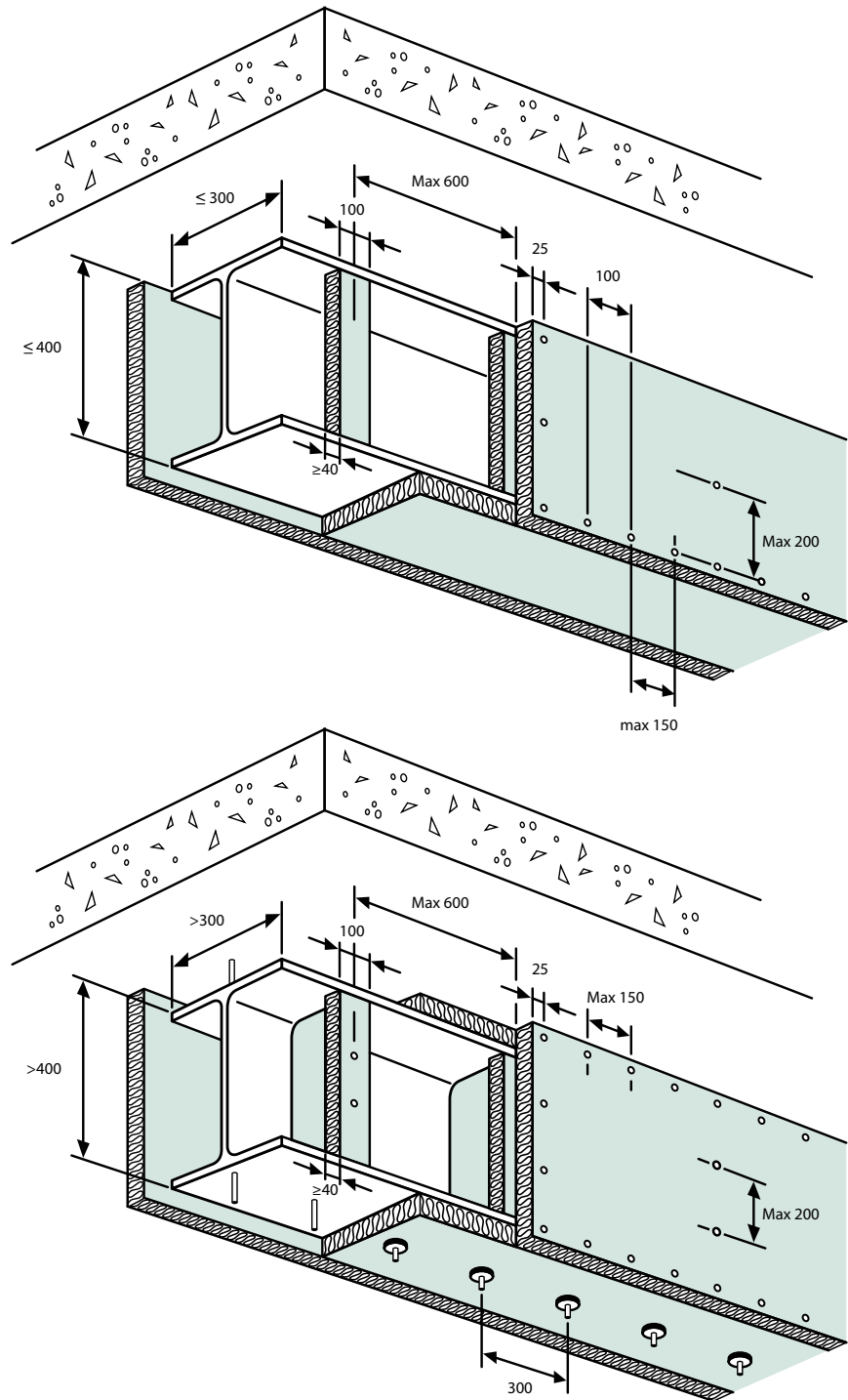
Paroc is one of Europe's leading manufacturers of energy-efficient and fire-proof insulation solutions. Throughout our 80-year history, we have earned a reputation for high product performance, technical expertise and sustainability among builders of single-family homes, architects, contractors, dealers and industrial builders. The cornerstones of our operations are customer and personnel orientation, constant innovation, profitable growth and sustainable development. Paroc products include building insulation, technical insulation, marine and offshore insulation, and acoustic products. The products are manufactured in Finland, Sweden, Lithuania, Poland and Russia. Paroc has sales and representative offices in 14 European countries.

BUILDING INSULATION
offers a wide range of products and solutions for all traditional building insulation. The building insulation products are mainly used for the thermal, fire and sound insulation of exterior walls, roofs, floors and basements, intermediate floors and partitions.

SOUND ABSORBING
ceilings and wall panels for interior acoustic control, as well as industrial noise control products, are available in the range.

TECHNICAL INSULATION
products are used for thermal, fire and sound insulation in HVAC systems, industrial processes and pipe work, industrial equipment as well as shipbuilding and offshore industry.

PAROC®