ETA 12/0114 +
EC5 + NA
Issued 07/2021

SPAX - Construction

Design guidelines

Guidelines for the design of structural connections with SPAX fasteners

MADE IN
GERMANY

June 2022

Table of contents

1. Introduction

This brochure applies for the calculation and execution of load-bearing screw connections according to
DIN EN 1995-1-1:2010-12 (Eurocode 5 or EC5)
DIN EN 1995-1-1/NA:2010-12 (National annex)
DIN EN 1995-1-1/NA/A1:2012-12 (Amendment A1 -draft-)

and according to the European Technical Assessment or ETA

ETA-12/0114
of January 07, 2020

It is used as a design aid for rapid dimensioning of load-bearing SPAX connections and does not replace the user's own written verification.

EC5 applies for the concept, calculation, dimensioning and execution, unless determined otherwise in the ETA. Solely requirements for the load-bearing capacity and usability of connections are covered.

Special design rules in addition to EC5 are specified in the corresponding sections and should be seen as the minimum requirement. If necessary, they must be extended for special types of connections. Components made of solid wood and laminated timber, cross-laminated timber, LVL, timber or layers of beam wood, wood-based products or steel parts may be connected to components made of solid wood and laminated timber, cross-laminated timber, LVL, timber or layers of beam wood.

Connections to chipboards incl. OSB boards, fibreboards or plywood can be implemented according to the approval of the respective wood-based product, in as far as connections with self-drilling wood screws are regulated in the approval of the wood-based product.

The brochure has been compiled to the best of our knowledge and belief. No liability is assumed for errors and obvious mistakes.

Corrections, questions and suggestions to technik@spax.com

The SPAX design software is also available for your project dimensioning in accordance with EC5 + ETA. The new browser version offers online dimensioning, including with the modules general screw dimensioning (shear + withdrawal), notch reinforcement, transverse pressure reinforcement, notch reinforcement and main/secondary beam connection with the option of server storage (file hosting) and project management. You can find a more detailed description of the program in the SPAX design software how-to guide at downloads.spax.com. To access the software directly use https://designsoftware.spax.com

For frequent use, we recommend adding a bookmark.

2. Definitions

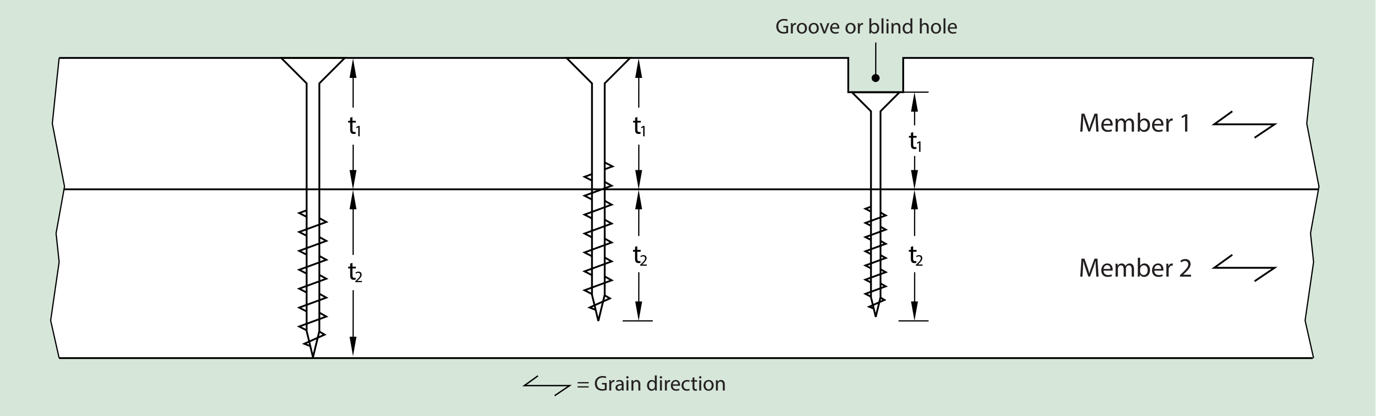
Formula symbols

$F_{v,Ed}$	Design value of the effect of loads perpendicular to the screw axis (shear forces)	[N]	
$F_{v,Ek}$	Characteristic value of the effect of loads perpendicular to the direction of the screw axis (shear forces)	[N]	
$F_{ax,\alpha,Ed}$	Design value of the effect of loads in the direction of the screw axis (withdrawal forces)	[N]	
$F_{ax,\alpha,Ek}$	Characteristic value of the effect of loads in the direction of the screw axis (withdrawal forces)	[N]	
$F_{v,Rd}$	Design value of the load-bearing capacity per shear plane and fastener for loads perpendicular to the screw axis (shear forces)	[N]	
$F_{v,Rk}$	Characteristic value of the load-bearing capacity per shear plane and fastener for loads perpendicular to the screw axis (shear forces)	[N]	EC5; 8.2.2 (1)
$F_{ax,\alpha,Rd}$	Design value for load-bearing capacity for loads in the direction of the screw axis	[N]	
$F_{ax,\alpha,Rk}$	Characteristic value for load-bearing capacity for loads in the direction of the screw axis per fastener (withdrawal)	[N]	ETA 3.9
$M_{y,k}$	Characteristic value of the yield moment	[Nm]	ETA 3.9
d_1	Outer thread diameter or nominal diameter	[mm]	ETA annexes
d_h	Head diameter	[mm]	ETA annexes
$f_{tens,d}$	Design value of the steel tensile capacity	[N]	
$f_{tens,k}$	Characteristic value of the steel tensile capacity	[N]	ETA 3.1
$f_{ax,k}$	Characteristic withdrawal parameter	[N/mm^2]	ETA 3.9
$f_{head,k}$	Characteristic head pull-through parameter	[N/mm^2]	ETA 3.9
$f_{h,\alpha,k}$	Characteristic value of the embedment strength	[N/mm^2]	ETA 3.9
k_{mod}	Modification coefficient (consideration of the service class and the load-duration class)	[ ]	EC5; Tab. 3.1 NA; Tab. NA. 1 and NA. 4
l_{ef}	Effective thread length in pointside member	[mm]	
$l_{ef,k}$	Effective thread length in headside member	[mm]	
l_g	Thread length of the screw	[mm]	ETA annexes
n_{ef}	Effective number of fasteners arranged in a row	[ ]	EC5; 8.7, ETA
t	Thickness, for example of a component	[mm]	
t_1	Wood thickness or penetration depth in wood 1	[mm]	
t_2	Wood thickness or penetration depth in wood 2	[mm]	
t_{req}	Required wood thickness or penetration depth	[mm]	
u_{gl}	Wood equilibrium moisture content	[%]	
α	Angle between screw axis and wood grain direction	[°]	ETA 3.9
α',ε	Angle between force direction and wood grain direction	[°]	
β	Ratio of embedment strengths $f_{h,2,k}/f_{h,1,k}$	[ ]	EC5; 8.2.2 (1)
γ_M	Partial safety factor for material properties under static or quasi-static loading	[ ]	EC5; Tab. 2.3 NA; Tab. NA.2 + NA.3
ΔR_k	Increase of the characteristic value of the load-bearing capacity R_k by a component ΔR_k (rope effect). $\Delta R_k = \min\{F_{ax,\alpha,Rk}/4;\ F_{v,Rk}\}$	[N]	EC5; 8.2.2 (2)
ρ_k	Characteristic density of the wood or the wood-based member	[kg/m^3]	Product norm

2. Designations

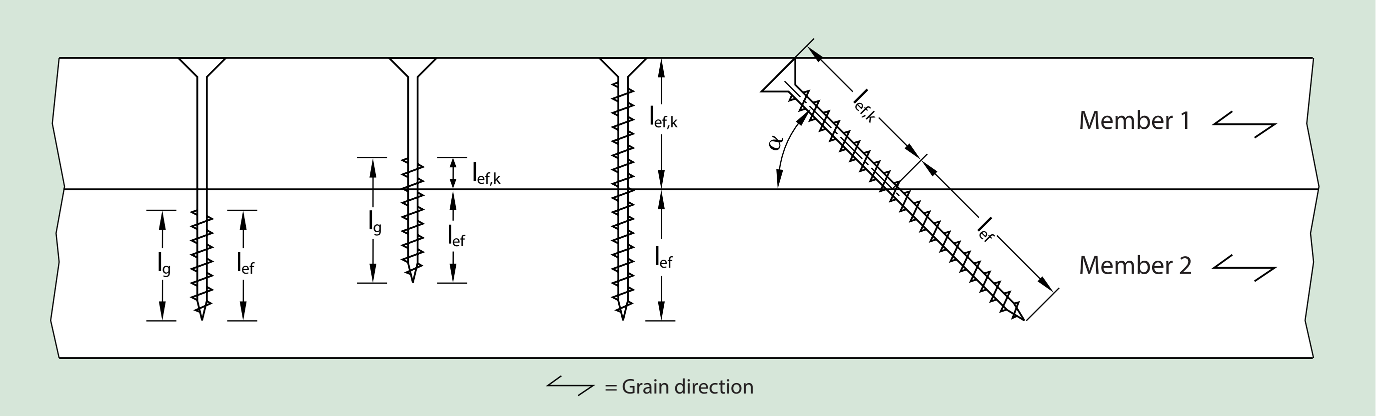
Dimensioning for loads perpendicular to the screw axis, shear

Figure 2.1 Determination of the wood thicknesses or penetration depths t_1 and t_2



Dimensioning for loads in the direction of the screw axis, withdrawal

Figure 2.2 Determination of effective thread lengths l_{ef} and $l_{ef,k}$



3. Verification of the load-bearing capacity

3.1 Shear forces

Design value for load-bearing capacity for loads perpendicular to the screw axis

$$F_{v,Rd} = \frac{k_{mod} \cdot F_{v,Rk}}{\gamma_M} \qquad [N] \qquad \gamma_M = 1.3$$

See section 5.1 for determination of the characteristic load-bearing capacity.

Verification of load-bearing capacity for loads perpendicular to the screw axis

The following requirement must be fulfilled:

$$\frac{F_{v,Rd}}{n_{ef} \cdot F_{v,Rd}} \leq 1$$

(If n_{ef} was already considered in $F_{v,Rd}$, do not consider again.)

3.2 Withdrawal forces

Design value for load-bearing capacity for loads in the direction of the screw axis

The design values of three different possible failure cases are compared to each other for dimensioning the load-bearing capacity for withdrawal forces.
The smallest of these values is decisive.

$$F_{ax,\alpha,Rd} = \min \begin{cases} \text{Design value } F_{ax,\alpha,Rd,2} \text{ based on failure in withdrawal of the thread} \\ \text{Design value } f_{tens,d} \text{ based on failure in tensile capacity (steel)} \\ \text{Design value } F_{ax,\alpha,Rd,1} = \max \{ F_{ax,\alpha,Rd,1} \, ; F_{ax,\alpha,Rhead,d,1} \} \text{ based on failure in head pull-through} \end{cases}$$

Design value withdrawal of the thread:

$$F_{ax,\alpha,Rd,2} = \frac{k_{mod} \cdot F_{Fax,\alpha,Rk,2}}{\gamma_M} \qquad [N] \qquad \gamma_M = 1.3$$

Design value tensile capacity (steel):

$$F_{tens,d} = \frac{k_{tens,k}}{\gamma_M} \qquad [N] \qquad \gamma_M = 1.3$$

Design value head pull-through:

$$F_{ax,\alpha,Rd,1} = \frac{k_{mod} \cdot \max \{ F_{ax,\alpha,Rk,1} \, ; F_{ax,\alpha,Rhead,k,1} \}}{\gamma_M} \qquad [N] \qquad \gamma_M = 1.3$$

Verification of load-bearing capacity for loads in the direction of the screw axis

The following requirement must be fulfilled:

$$\frac{F_{ax,\alpha,Ed}}{n_{ef} \cdot F_{ax,\alpha,Rd}} \leq 1$$

(If n_{ef} was already considered in $F_{ax,\alpha,Rd,}$ do not consider again.)

Verification of load-bearing capacity for combined loads perpendicular to the direction and in the direction of the screw axis

ETA 3.9

The following requirement must be fulfilled:

$$\left(\frac{F_{v,Ed}}{n_{ef} \cdot F_{v,Ed}} \right)^2 + \left(\frac{F_{ax,\alpha,Ed}}{n_{ef} \cdot F_{ax,\alpha,Rd}} \right)^2 \leq 1$$

(If n_{ef} was already considered in $F_{v,Rd}$ and in $F_{ax,\alpha,Rd,}$ do not consider again.)

4. Design value coefficients k_{mod} and γ_M

4.1 Modification coefficient k_{mod}

The modification coefficient k_{mod} considers the influence of the service class and the load-duration class on the strength properties of the wood or the wood-based materials.

EC5; Tab. 3.1
NA; Tab. NA.4

Determination of the modification coefficient k_{mod} takes place in 3 steps:

1. Determination of the service class
2. Determination of the load-duration class according to the decisive loading condition combination
3. Determination of the calculation value of the modification coefficient k_{mod} by means of the previously determined service class and load-duration class

Service class

In view of the physical properties of the wood as a building material, wood structures have to be assigned to specific service classes, which identify the environmental conditions of the structure during its usage.

EC5; 2.3.1.3

Service class 1: This is characterised by a wood moisture, which corresponds to a temperature of 20 °C and a relative humidity of the ambient air which exceeds a value of 65 % for only a few weeks of the year, for example in all-around closed and heated structures.

Service class 2: This is characterised by a wood moisture, which corresponds to a temperature of 20 °C and a relative humidity of the ambient air which exceeds a value of 85 %, for only a few weeks of the years, for example for roofed open structures.

Service class 3: This encompasses climatic conditions which lead to higher wood moistures than specified in Service class 2, for example for structures which are exposed to the elements.

Table 4.1 Overview of service class classification

	A	B	C	D
1	**SC**	Ambient climate[a]	Installation situation	Mean wood moisture u_{gl}
2	**1**	20 °C/rel. humidity ≤ 65 %	Closed all-around	5 % – 15 %[b]
3	**2**	20 °C/rel. humidity ≤ 85 %	Roofed open	10 % – 20 %[c]
4	**3**	Higher humidity level than in SC 2	Exposed to the elements without protection	12 % – 24 %

[DIN 1052; E 7.1.1 (4)]

Note:
In exceptional cases roofed components can also be classified in the Service class 3.
Properly performed coverings can allow outside components to be classified in SC 2.

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[a] The specified ambient climatic conditions can be exceeded for a few weeks in the year.
[b] In most woods a medium equilibrium moisture of u = 12 % is not exceeded in SC 1.
[c] In most woods a medium equilibrium moisture of u = 20 % is not exceeded in SC 2.

4. Design value coefficients k_{mod} and γ_M

4.1 Modification coefficient k_{mod}

Load-duration class LDC

Table 4.2 Classification of the effects according to DIN EN 1991-1-1, DIN EN 1991-1-3, DIN EN 1991-1-4, DIN EN 1991-1-7, DIN EN 1991-3 and the associated national annexes in load-duration classes (LDC)

NA; Tab. NA.1

	A	B
1	**Effect**	**LDC**
2	**Densities and weights** according to DIN EN 1991-1-1	Permanent
3	**Perpendicular load capacities** according to DIN EN 1991-1-1	
4	A Attics, living rooms and lounges	Medium-term
5	B Office areas, work areas, corridors	Medium-term
6	C Rooms, meeting rooms and areas which can be used for the aggregation of persons (with exception of categories specified under A, B, D and E)	Short-term
7	D Salesrooms	Medium-term
8	E1 Storage areas, factories and workshops, stables, storage rooms and accesses	Long-term
9	E2 Surfaces for operation with forklifts	Medium-term
10	F Roads and parking areas for light vehicles (overall load $<$ 30 kN), access ramps to these areas	Medium-term Short-term
11	H Non-accessible roofs, apart from usual maintenance measures, repairs	Short-term
12	K Helicopter normal loads	Short-term
13	T Stairs and stair landings	Short-term
14	Z Accesses, balconies and similar	Short-term
15	**Horizontal loads** according to DIN EN 1991-1-1	
16	Horizontal load capacities as a result of persons on balustrades, railings and other structures which are used as barriers	Short-term
17	Horizontal loads to achieve sufficient longitudinal and transverse rigidity	a
18	Horizontal loads for helipads on roofings, - For horizontal load capacities, - For rollover protection	Short-term Instantaneous
19	**Wind loads** according to DIN EN 1991-1-4	Short / instantaneous
20	**Snow load and ice load** according to DIN EN 1991-1-3	
21	Ground elevation of the structure location above sea level $\leq$ 1,000 m	Short-term
22	Ground elevation of the structure location above sea level $>$ 1,000 m	Medium-term
23	**Impact loads** according to DIN EN 1991-1-7	Instantaneous
24	**Horizontal loads from crane and machine operation** according to DIN EN 1991-3	Short-term

Effects from temperature as well as moisture and humidity changes can be assigned to the load-duration class “Medium-term”. NA; 2.3.1.2(2)P

Effects from uneven subsidences can be assigned to the class of the exposure duration “Permanent”. NA; 2.3.1.2(2)P

For wood components the influence of temperature changes may be ignored. NA; 2.3.1.2(2)P

For effects within a loading condition combination with different LDCs, the LDC with the shortest duration may be assumed for the determination of the modification efficient $k_{mod.}$ EC5; 3.1.3 (2)

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[a] Corresponding to the associated loads

[b] In case of wind the average of Short term and Instantaneous may be used for k_{mod}

4. Design value coefficients k_{mod} and γ_M

4.1 Modification coefficient k_{mod}

Table 4.3 Calculation values for the modification coefficients k_{mod}

EC5; Tab. 3.1

	A	B	C	D	E	F	G	H
1	**Building material**	**Norm**	**Service class**	**Load-duration class**				
				Permanent	**Long-term**	**Medium-term**	**Short-term**	**Instantaneous**
2	Solid wood	EN 14081-1	1	0.60	0.70	0.80	0.90	1.10
3			2	0.60	0.70	0.80	0.90	1.10
4			3	0.50	0.55	0.65	0.70	0.90
5	Laminated timber	EN 14080	1	0.60	0.70	0.80	0.90	1.10
6			2	0.60	0.70	0.80	0.90	1.10
7			3	0.50	0.55	0.65	0.70	0.90
8	LVL	EN 14374,	1	0.60	0.70	0.80	0.90	1.10
9		EN 14279	2	0.60	0.70	0.80	0.90	1.10
10			3	0.50	0.55	0.65	0.70	0.90
11	Plywood	EN 636						
12		Type EN 636-1	1	0.60	0.70	0.80	0.90	1.10
13		Type EN 636-2	2	0.60	0.70	0.80	0.90	1.10
14		Type EN 636-3	3	0.50	0.55	0.65	0.70	0.90
15	OSB	EN 300						
16		OSB/2	1	0.30	0.45	0.65	0.85	1.10
17		OSB/3, OSB/4	1	0.40	0.50	0.70	0.90	1.10
18		OSB/3, OSB/4	2	0.30	0.40	0.55	0.70	0.90
19	Chipboards	EN 312						
20		Type P4, Type P5	1	0.30	0.45	0.65	0.85	1.10
21		Type P5	2	0.20	0.30	0.45	0.60	0.80
22		Type P6, Type P7	1	0.40	0.50	0.70	0.90	1.10
23		Type P7	2	0.30	0.40	0.55	0.70	0.90
24	Fibreboards, hard	EN 622-2						
25		HB.LA, HB.HLA1 or 2	1	0.30	0.45	0.65	0.85	1.10
26		HB.HLA1 or 2	2	0.20	0.30	0.45	0.60	0.80
27	Fibreboards, medium hard	EN 622-3						
28		MBH.LA1 or 2	1	0.20	0.40	0.60	0.80	1.10
		MBH.HLS1 or 2	1	0.20	0.40	0.60	0.80	1.10
29		MBH.HLS1 or 2	2	-	-	-	0.45	0.80
30	Fibreboards, MDF	EN 622-5						
31		MDF.LA, MDF.HLS	1	0.20	0.40	0.60	0.80	1.10
32		MDF.HLS	2	-	-	-	0.45	0.80

EC5; 2.3.2.1(2)

If the modification coefficients k_{mod} differ for the two components ($k_{mod,1}$ and $k_{mod,2}$) that are connected to each other at connections between wood-based products and wood, the following value may be assumed for k_{mod}:

NA; Eq. (NA.114)

$$k_{mod} = \sqrt{k_{mod,1} \cdot k_{mod,2}}$$

4. Design value coefficients k_{mod} and γ_M

4.1 Modification coefficient k_{mod}

Table 4.4 Calculation values for the modification coefficients k_{mod} for wood, wood and gypsum materials

NA; Tab. NA.4

	A	B	C	D	E	F	G	H
1	**Building material**	**Norm**	**Service class**	**Load-duration class**				
				Permanent	**Long-term**	**Medium-term**	**Short-term**	**Instantaneous**
2	Laminated timber, cross-laminated timber, solid wood boards		1	0.60	0.70	0.80	0.90	1.10
3			2	0.60	0.70	0.80	0.90	1.10
4	Plasterboards (types GKBa, GKFa, GKBI and GKFI), gypsum fibreboards	DIN 18180, DIN EN 15283-2	1	0.20	0.40	0.60	0.80	1.10
5			2	0.15	0.30	0.45	0.60	0.80
6	Cement-bonded		1	0.30	0.45	0.65	0.85	1.10
7	Chipboards		2	0.20	0.30	0.45	0.60	0.80
8	[a] Only Service class 1:							

4.2 Partial safety factor γ_M for material properties

Table 4.5 Partial safety factor γ_M for material properties under static or quasi-static loading

NA; Tab. NA.2 + NA.3

	A	B
1	**Building material**	γ_M
2	Solid wood, chipboards, hard fibreboards, medium hard fibreboards, MDF fibreboards, soft fibreboards, LVL, plywood, OSB, laminated timber	1.3
3	Laminated timber, cross-laminated timber, solid wood boards, fibre-reinforced plasterboards, plasterboards, cement-bound chipboards	1.3
4	Steel in connections	
5	- For pin-shaped fasteners loaded by bending	1.3
6	- For parts loaded by pulling or shear forces during verification of the yield strength in the net cross-section	1.3
7	- Plate verification for load-bearing capacity for nailing plates	1.25

The partial safety factors for the verification of steel parts are specified in DIN EN 1993 or the respective national annexes.
For exceptional dimensioning situations the partial safety factors γ_M are to be set to 1.0.

NA; 2.4.1

5.1 Shear forces

5.1.1 Load-bearing capacity for loads perpendicular to the screw axis according to EC5

Dimensioning of the load-bearing capacity for shearing forces takes place according to EC5. The basis of the exact verification process are the dimensioning equations according to Johansen under consideration of different failure types.

EC5; 8.2

The characteristic load-bearing capacity for pin-shaped fasteners is to be assumed as the smallest value from the following expressions:

- For single shear connections:

EC5; Eq. (8.6)

$$F_{v,Rk} = \min \begin{cases} f_{h,\alpha,1,k} t_1 d_1 & \text{(a)} \\ f_{h,\alpha,2,k} t_2 d_1 & \text{(b)} \\ \frac{f_{h,\alpha,1,k} t_1 d_1}{1+\beta} \left[\sqrt{\beta + 2\beta^2 \left[1 + \frac{t_2}{t_1} + \left(\frac{t_2}{t_1} \right)^2 \right] + \beta^3 \frac{t_2}{t_1}} - \beta \left(1 + \frac{t_2}{t_1} \right) \right] + \frac{F_{ax,\alpha,Rk}}{4} & \text{(c)} \\ 1{,}05 \frac{f_{h,\alpha,1,k} t_1 d_1}{2+\beta} \left[\sqrt{2\beta(1+\beta) + \frac{4\beta(2+\beta) M_{y,Rk}}{f_{h,\alpha,1,k} d_1 t_1^2}} - \beta \right] + \frac{F_{ax,\alpha,Rk}}{4} & \text{(d)} \\ 1{,}05 \frac{f_{h,\alpha,1,k} t_2 d_1}{1+2\beta} \left[\sqrt{2\beta^2(1+\beta) + \frac{4\beta(1+2\beta) M_{y,Rk}}{f_{h,\alpha,1,k} d_1 t_2^2}} - \beta \right] + \frac{F_{ax,\alpha,Rk}}{4} & \text{(e)} \\ 1{,}15 \sqrt{\frac{2\beta}{1+\beta}} \sqrt{2 M_{y,Rk} f_{h,\alpha,1,k} d_1} + \frac{F_{ax,\alpha,Rk}}{4} & \text{(f)} \end{cases}$$

Load-bearing capacity from embedding in wood components — Rope effect (ΔR_k)

with

$M_{y,Rk}$ = Characteristic value of the yield moment according to ETA
$F_{ax,\alpha,Rk}$ = Characteristic value of the load-bearing capacity (withdrawal forces)
β = $f_{h,\alpha,2,k} / f_{h,\alpha,1,k}$ (EC5; 8.2.2)
with
  $f_{h,\alpha,1,k}$ = Characteristic value of the embedment strength wood 1 (head-side)
  $f_{h,\alpha,2,k}$ = Characteristic value of the embedment strength wood 2 (point-side)
t_1, t_2 = Thickness of the wood component 1/ penetration depth in wood 2

5.1 Shear forces

5.1.1 Load-bearing capacity for loads perpendicular to the screw axis according to EC5

The load-bearing capacity of embedding in the wood components amongst other depends on the characteristic value of the embedment strength $f_{h,\alpha,k}$ and is regulated in the SPAX ETA.

The embedment strength for screws in non-pre-drilled wood components, which are arranged at an angle of $0° \leq \alpha \leq 90°$ between the screw axis and grain direction, amounts to:

$$f_{h,\alpha,k} = \frac{0.082 \cdot \rho_k \cdot d_1^{-0.3}}{2.5 \cdot \cos^2 \alpha + \sin^2 \alpha} \qquad [N/mm^2]$$

For pre-drilled wood components:

$$f_{h,\alpha,k} = \frac{0.082 \cdot \rho_k \cdot (1-0{,}01 \cdot d_1)}{2.5 \cdot \cos^2 \alpha + \sin^2 \alpha} \qquad [N/mm^2]$$

For SPAX threaded rods in pre-drilled wood components:

$$f_{h,\alpha,k} = \frac{0.082 \cdot \rho_k \cdot (1-0{,}01 \cdot d_1)}{(2.5 \cdot \cos^2\alpha + \sin^2\alpha) \cdot (k_{90} \cdot \sin^2\varepsilon + \cos^2\varepsilon)} \qquad [N/mm^2]$$

with

ρ_k = Characteristic density of the wood or the wood-based member [kg/m³];
d_1 = Thread diameter [mm];
α = Angle between screw axis and wood grain direction;
ε = Angle between force direction and wood grain direction;
k_{90} = according to EC5 Eq. (8.33)

The following applies for cross-laminated timber:
The embedment strength for screws which are arranged in parallel to the plate plane of cross-laminated timber is to be calculated independently of the angle between the screw axis and grain direction $0° \leq \alpha \leq 90°$ as follows:

$$f_{h,\alpha,k} = 20 \cdot d_1^{-0.5} \qquad [N/mm^2]$$

in as far as nothing to the contrary is specified in the technical specifications (ETA or hEN) for the laminated timber plate.

Where
d_1 Outer thread diameter [mm]

The embedment strength for screws or threaded rods in the plane surface of cross-laminated timber has to be calculated as with solid wood on the basis of the characteristic values of the bulk density of the outer layer. For SPAX threaded rods the angle between the force direction and wood grain direction of the outer layer must be considered.

The direction of the lateral forces must run transversely to the screw axis and parallel to the plane surface of the cross-laminated timber.

In general:
For screws subject to transverse loads the rules for multiple connections in EN 1995-1-1, 8.3.1.1 (8) should be applied.

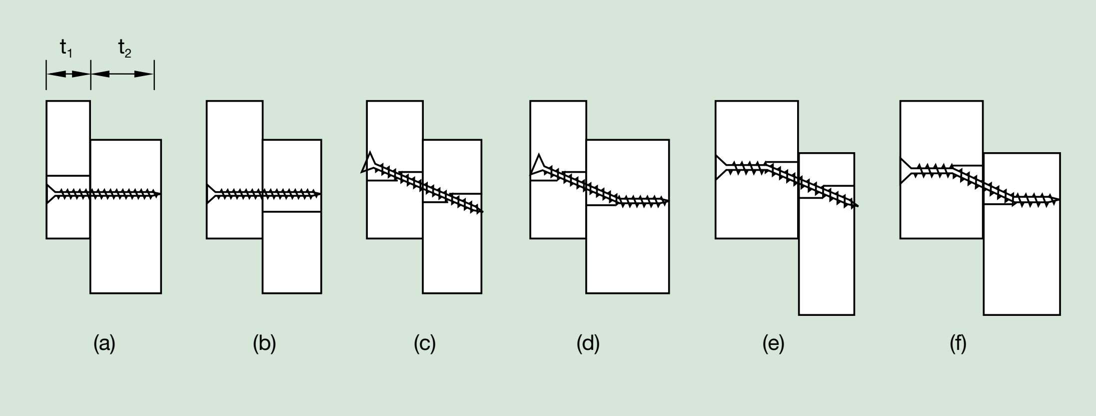
See section 5.1. 2 Determination of the effective number n_{ef} of fasteners arranged in a row.

5.1 Shear forces

5.1.1 Load-bearing capacity for loads perpendicular to the screw axis according to EC5

Figure 5.1 Failure types for the dimensioning equations according to Johansen

EC5; Eq. (8.6)



(a) Embedding failure in wood component 1, (b) embedding failure in wood component 2, (c) embedding failure in wood components 1 and 2, (d) embedding failure in wood component 1 and formation of a reinforcement flow of the screw part in wood component 2, (e) embedding failure in wood component 2 and formation of the reinforcement flow of the screw part in wood component 1, (f) formation of two reinforcement flows of the screw in wood components 1 and 2

The failure types depend on the embedding of the screw part in the respective wood component, which in turn depends on the bulk density and the wood thickness. The maximum load-bearing capacity of a pin-shaped fastener is reached in failure type (f) when two reinforcement flows are formed in the fastener. To be able to predict the failure case (f) it is necessary to predict a minimum embedding thickness t_{req} depending on the characteristic density ρ_k.

For verification with the load-bearing capacity tables in section 7 for loads perpendicular to the screw axis, the formation of two reinforcement flows in the respective fastener is required.

Therefore compliance with minimum wood thickness or minimum penetration depth for the application of the load-bearing capacity tables according to section 7 is necessary.

The dimensioning of the load-bearing capacity for shearing forces usually takes in multiple steps:

1. Determination of the minimum wood thickness or minimum penetration depth t_{req}
2. Determination of the characteristic load-bearing capacity $F_{v,Rk}$ for shear forces
3. Increase in the characteristic value of the load-bearing capacity by a share ΔR_k (rope effect)
4. Determination of the effective number n_{ef} of fasteners arranged in a row

The load-bearing capacity tables in section 7 only consider single shear connections.

Increase in the load-bearing capacity by the “Rope effect” ΔR_k in failure types (c) to (f)

$\Delta R_k = \min \{F_{ax,\alpha,Rk}/4 \, ; \, F_{v,Rk}\}$

For SPAX screws and threaded rods the rope effect ΔR_k can be assumed with an increase of up to 100 % of the characteristic value of the load-bearing capacity from embedding in wood components. Provided that the characteristic value of the load-bearing capacity for withdrawal force is at least 4 times as high as the characteristic value of the load-bearing capacity from embedding in the wood component.

The table values of the characteristic load-bearing capacity listed in chapter 7 correspond to the load-bearing capacity from embedding according to failure type (f) for woods with the same characteristic density with $\beta = 1.0$.

5.1 Shear forces

5.1. 2 Determination of the effective number n_{ef} of fasteners arranged in a row

EC5; 8.3.1.1 (8)

With a series with n screws in the grain direction of the wood, the **load-bearing capacity in the grain** direction should be calculated with an effective number n_{ef} when the screws in this row perpendicular to the grain direction are not offset to each other by at least $1 \cdot d_1$ (see Figure 5.2). With: $n_{ef} = n^{kef}$

Figure 5.2 Effective number n_{ef}

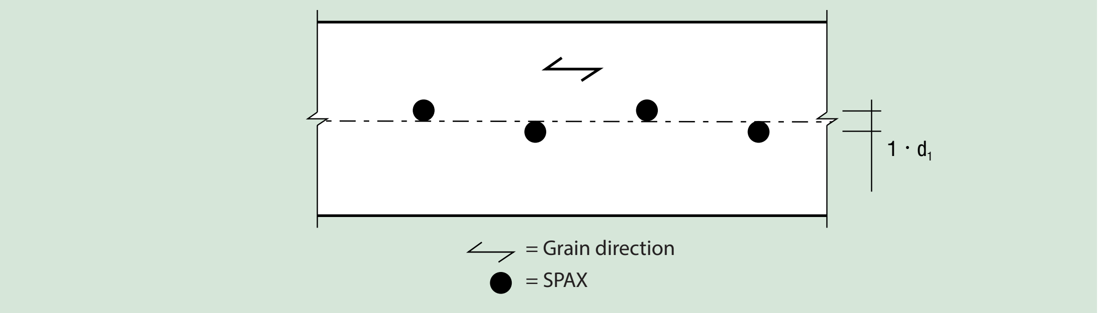


Table 5.1 Effective number n_{ef} depending on the minimum spacing a_1

EC5; Eq. (8.17)

	A	B	C	D	E	F	G	H	I
1	SPAX	Effective number n_{ef}		Effective number n_{ef}		Effective number n_{ef}		Effective number n_{ef}	
2		$k_{ef} = 0.5$		$k_{ef} = 0.567$		$k_{ef} = 0.85$		$k_{ef} = 0.925$	
3		$a_1 = 4 \cdot d_1$ [a]		$a_1 = 5 \cdot d_1$ [a]		$a_1 = 10 \cdot d_1$ a		$a_1 = 12 \cdot d_1$ [a]	
4		Pre-drilled		Pre-drilled, not pre-drilled		Pre-drilled, not pre-drilled		Pre-drilled, not pre-drilled	
5	n	$\alpha' = 0°$	$\alpha' = 90°$	$\alpha' = 0°$	$\alpha' = 90°$	$\alpha' = 0°$	$\alpha' = 90°$	$\alpha' = 0°$	$\alpha' = 90°$
6	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
7	2	1.4	2.0	1.5	2.0	1.8	2.0	1.9	2.0
8	3	1.7	3.0	1.9	3.0	2.5	3.0	2.8	3.0
9	4	2.0	4.0	2.2	4.0	3.2	4.0	3.6	4.0
10	5	2.2	5.0	2.5	5.0	3.9	5.0	4.4	5.0
11	6	2.4	6.0	2.8	6.0	4.6	6.0	5.2	6.0
12	7	2.6	7.0	3.0	7.0	5.2	7.0	6.0	7.0
13	8	2.8	8.0	3.2	8.0	5.9	8.0	6.8	8.0
14	9	3.0	9.0	3.5	9.0	6.5	9.0	7.6	9.0
15	10	3.2	10.0	3.7	10.0	7.1	10.0	8.4	10.0
16	[a] A linear interpolation for k_{ef} is permissible for intermediate values of the screw spacings.								

α' is the angle between the force direction and wood grain direction

NA; 8.5 (NA.7)
+ 8.6, (NA.9)

If wood splitting is prevented by a reinforcement perpendicular to the grain direction, you may set $n_{ef} = n$ for connections with bolts, rod dowels or fitted bolts.

For $a_1 \geq 14 \cdot d_1$ $k_{ef} = 1$ is assumed, $n_{ef} = n$.

Table 5.2 Calculation values for k_{ef} depending on distance a_1

EC5; Tab. 8.1

	A	B	C	D	E	F	G	H	I	J	K	L
1	a_1	4	5	6	7	8	9	10	11	12	13	14
2	Not pre-drilled	-	0.5667	0.6333	0.7	0.75	0.8	0.85	0.8875	0.925	0.9625	1.0
3	Pre-drilled	0.5	0.5667	0.6333	0.7	0.75	0.8	0.85	0.8875	0.925	0.9625	1.0

5.2 Load-bearing capacity withdrawal / pressing forces

Load-bearing capacity for loads in the direction of the screw axis (withdrawal forces)

For the dimensioning of the load-bearing capacity at withdrawal forces, the dimensioning values of three possible failure cases are determined according to section 3.9 of the SPAX ETA. The smallest of the values becomes decisive.

$F_{ax,\alpha,Rd}$ = min

5.2.1	Design value $F_{ax,\alpha,Rd,2}$ failure case withdrawal force of the point-end thread, wood component 2	-> Tab. 7.14
5.2.2	Design value $f_{tens,d}$ failure case tensile capacity (steel)	-> Tab. 7.15
5.2.3	Design value head pull-through failure through the head-side wood component 1 as a maximum of the failure cases:	
Max.	design value head pull-through $F_{ax,\alpha,Rhead,d,1}$	-> Tab. 7.16.1 to 7.16.3
	design value thread withdrawal $F_{ax,\alpha,Rd,1}$	-> Tab. 7.14

Determination of the design values, see 3. Verification of the load-bearing capacity (page 6).

5.2.1 Characteristic value of withdrawal resistance of the threaded part $F_{ax,\alpha,Rk,2}$

$$F_{ax,\alpha,Rk} = \frac{n_{ef}\cdot f_{ax,k}\cdot d_1\cdot l_{ef}}{1,2\cdot\cos^2\alpha+\sin^2\alpha}\left(\frac{\rho_k}{350}\right)^{0,8}$$

[N] ETA 3.9

with

$F_{ax,\alpha,Rk}$	Characteristic value of the load-bearing capacity in the screw axis below an angle *a* between the screw axis and wood grain direction [N]		
n_{ef}	$n_{ef} = n^{0.9}$ or $n_{ef} = \max\{n^{0.9} ; n\cdot 0.9\}$	See 5.2.4	EC5 or ETA 3.9
$f_{ax,k}$	Characteristic withdrawal parameter		ETA 3.9
	$2.5\text{ mm} \le d_1 < 6.0\text{ mm}$: $f_{ax,k} = 14.0\text{ N/mm}^2$		
	$6.0\text{ mm} \le d_1 < 8.0\text{ mm}$: $f_{ax,k} = 12.0\text{ N/mm}^2$		
	d= 10.0 mm: $f_{ax,k} = 11.5\text{ N/mm}^2$		
	d= 12.0 mm: $f_{ax,k} = 11.0\text{ N/mm}^2$		
	d= 16.0 mm: $f_{ax,k} = 10.0\text{ N/mm}^2$		
d_1	Outer thread diameter	[mm]	ETA
l_{ef}	Effective thread length in wood component		
	l_{ef} for $F_{ax,\alpha,Rk,2}$ in point-side wood component	[mm]	
	$l_{ef,k}$ for $F_{ax,\alpha,Rk,1}$ in head-side wood component including head	[mm]	
α	Angle between screw axis and wood grain direction For screw withdrawal $\alpha \ge 15°$ for components made of solid wood made of softwood and hardwood up to 730 kg/m³ and $\alpha \ge 30°$ for LVL made of softwood and hardwood up to 750 kg/m³.		
ρ_k	Characteristic density of the respective wood component	[kg/m³]	

5.2 Load-bearing capacity withdrawal / pressing forces

5.2.2 Characteristic value $f_{tens,k}$ tensile capacity (steel)

The characteristic value of the steel tensile capacity $f_{tens,k}$ is specified in the ETA. ETA 3.1

The design value of the steel tensile capacity is determined with $\gamma_M = 1.3$: NA; Tab. NA.2

$f_{tens,d} = f_{tens,k} / \gamma_M$ [N]

5.2.3 Characteristic value head pull-through failure max $\{F_{ax,\alpha,Rhead,k,1}$; $F_{ax,\alpha,Rk,1}\}$

The head pull-through $F_{ax,\alpha,Rhead,k,1}$ is compared with the withdrawal of the thread $F_{ax,\alpha,Rk,1}$.

$$\text{Max.}\begin{cases} F_{ax,\alpha,Rhead,k,1} = n_{ef}\cdot k_t\cdot f_{head,k}\cdot d_h^{\,2}\cdot\left(\dfrac{\rho_k}{350}\right)^{0.8} \\[2ex] F_{ax,\alpha,Rk,1} = \dfrac{n_{ef}\cdot f_{ax,k}\cdot d_1\cdot l_{ef,k}}{1{,}2\cdot\cos^2\alpha+\sin^2\alpha}\cdot\left(\dfrac{\rho_k}{350}\right)^{0.8}\end{cases} \quad [N]$$

ETA 3.9

Head pull-through $F_{ax,\alpha,Rhead,k,1}$

with

n_{ef}	$n_{ef} = n^{0.9}$ or $n_{ef} = \max\{n^{0.9} ; n\cdot 0{,}9\}$	See 5.2.4	EC5 or ETA 3.9
k_t	Factor for consideration of the head-side wood thickness t_1 ($t_h = t_1$) $k_t = 1$ for $t_1/d_h < 3$ $k_t = 1.3$ for $t_1/d_h \geq 3$		ETA 3.9
$f_{head,k}$	Characteristic head pull-through parameter		ETA 3.9
d_h	Head diameter		
$l_{ef,k}$	For $F_{ax,\alpha,Rk,1}$ in head-side wood component including head		

5.2 Load-bearing capacity withdrawal / pressing forces

5.2.3 Characteristic value head pull-through failure max {$F_{ax,\alpha,Rhead,k,1}$; $F_{ax,\alpha,Rk,1}$}

ETA 3.9

Table 5.2.3 Head pull-through parameter $f_{head,k}$ depending on head form and head diameter for connections with wood components with a minimum thickness of $t_1 \geq 20$ mm [N/mm^2]

	A	B
1	Flat countersunk head	
2	d_h	$f_{head,k}$
3	≤ 16 mm	27.0 - d_h
4	16 < d_h ≤ 32 mm	11.0 - 0.2 · (d_h - 16)
5	Washer head, pan head, flat countersunk head with washer or with fixing thread	
6	d_h	$f_{head,k}$
7	≤ 16 mm	29 - d_h
8	16 mm < d_h ≤ 22 mm	13.0
9	22 mm < d_h ≤ 32 mm	16.0 - 0.5 · (d_h - 16)

When connecting wood-based products with thickness 12 mm ≤ t_1 ≤ 20 mm:
$f_{head,k} = 8$ N/mm^2

When connecting wood-based products with a thickness $t_1 < 12$ mm (however, at least a thickness of $t_1 \geq 1.2 \cdot d_1$ with d_1 as the outer thread diameter
Limited to $F_{ax,\alpha,Rk} = 400$ N

d_h	Diameter of the screw head or the washer. Head diameters or washer diameters with a diameter $d_h > 32$ mm may only be used for calculation with a diameter of $d_h = 32$ mm.
ρ_k	Characteristic density of the wood component. For engineered wood boards $_k$= 380 kg/m^3

Head pull-through does not become decisive for sheet metal to wood connections.

Thread withdrawal $F_{ax,\alpha,Rk,1}$

See section 5.2.1 Characteristic value of withdrawal resistance of the threaded part $F_{ax,\alpha,Rk,2}$

5.2 Load-bearing capacity withdrawal / pressing forces

5.2.4 Determination of the effective number n_{ef} of screw groups

For screws under tensile stress at which the external force runs in parallel to the screw axis, the effective number of screws n_{ef} is determined according to EC5; 8.7.2 (8).

EC5; 8.7.2 (8)

For suitable screws in wood to wood or steel to wood shear forces where the screws are arranged at an angle of $30° \leq \alpha \leq 60°$ between shear surface and screw axis, the effectively effective number of screws n_{ef} should be determined as follows:

ETA; 3.9

For a series with screws parallel to the load, the loading-bearing capacity should be determined by means of the effectively effective number of fastenings n_{ef} whereby

$$n_{ef} = \max \{ n^{0.9} ; 0.9 \cdot n \}$$

n The number of the inclined screws in a series. If crossed pairs of screws are used in wood to wood connections, n is the number of crossed pairs of screws in a row.

Note: For screws as transverse pressure reinforcement or inclined screws as fastenings in beams or pillars with flexible joints or the attachment of on roof insulation systems $n_{ef} = n$.

Table 5.2.4 Effective number n_{ef} of SPAX loaded in the shaft direction $n_{ef} = n^{0.9}$

	A	B	C	D	E	F	G	H	I	J	K	L
1	n	n_{ef}	n	n_{ef}	n	n_{ef}	n	n_{ef}	n	n_{ef}	n	n_{ef}
2	1	1.0	6	5.0	11	8.7	16	12.1	21	15.5	26	18.8
3	2	1.9	7	5.8	12	9.4	17	12.8	22	16.2	27	19.4
4	3	2.7	8	6.5	13	10.1	18	13.5	23	16.8	28	20.1
5	4	3.5	9	7.2	14	10.8	19	14.2	24	17.5	29	20.7
6	5	4.3	10	7.9	15	11.4	20	14.8	25	18.1	30	21.4

EC5, Eq. (8.41)

5.2 Load-bearing capacity withdrawal / pressing forces

5.2.5 Load-bearing capacity for loads in the direction of the screw axis (pressing force)

The design values of two different possible failure cases are compared to each other for dimensioning the load-bearing capacity for pressing force. The smallest value is decisive.

ETA; 3.9

$$F_{ax,\alpha,Rd} = \min \begin{cases} \dfrac{f_{ax,d} \cdot d_1 \cdot l_{ef}}{1.2 \cdot \cos^2\alpha + \sin^2\alpha} \cdot \left(\dfrac{\rho_k}{350}\right)^{0.8} & \text{-> Tab. 7.14} \\ \\ \dfrac{\kappa_C \cdot N_{pl,k}}{\gamma_{M1}} & \text{-> Tab. 7.17} \end{cases}$$

5.2.6 Reinforcement of transverse-loaded wood components

The dimensioning values of two possible failure cases are determined for dimensioning the loads for a pressure surface with SPAX full-thread screws screwed in at an angle of 45° $\leq \alpha \leq$ 90°.

$$F_{90,Rd} = \min \begin{cases} k_{c,90} \cdot B \cdot l_{ef,1} \cdot f_{c,90,d} + n \cdot F_{ax,\alpha,Rd} \\ B \cdot l_{ef,2} \cdot f_{c,90,d} \end{cases}$$

ETA; Annex C Eq. (C.1)

N = number of available screws, do not reduce to n_{ef}.

$F_{ax,\alpha,Rd}$ = see 5.2.5 Load-bearing capacity for loads in the direction of the screw axis (pressing force)

Further information and a calculation example are available in the SPAX wood construction reports No. 3A, 3B and 3C

6. Installation guidelines

In addition to dimensioning, the SPAX ETA also regulates proper execution of load-bearing wood connections. As with dimensioning, EC5 + NA, amongst others, also applies for the execution, if nothing to the contrary is specified in the ETA.

For approved wood components the corresponding approvals must be observed, as appropriate.

The specifications for the execution of load-bearing wood connections have the purpose of preventing premature splitting of the connection, or of the respective wood components, before reaching the statically dimensioned load-bearing capacity for the dimensioned state.

Thus, for example, the minimum wood thicknesses t_{min} specified below must not be confused with the minimum wood thickness t_{req}. The minimum wood thickness t_{req} is a prerequisite that the reinforcement flows which are required as verification for loads perpendicular to the screw axis (shear forces) can form in the screw.

6.1 General

Penetration depths $l_{ef} < 4 \cdot d_1$ shall not be used in calculation. Applies for shear forces and withdrawal forces.

The screw thread may also be in the connected wood part.

Countersunk head screws must not be used with washers.

In as far as wood components pressed under an angle to the grain are reinforced with SPAX full-thread screws, it must be ensured that the compressive force is distributed evenly amongst all reinforcing screws and that the pressing force resulting from the screw heads can be absorbed by the support material. (Select screws of the same length, place sufficiently thick steel plate underneath)

Solid wood for end-grain connections should at least be cut in core-separated and should have a maximum wood moisture of 18 % during the establishment of the connection.

Cross-sectional weakenings should be considered mathematically for SPAX screws or threaded rods with a diameter of $d_1 \geq 10.0$ mm. For screws in pre-drilled components the drill hole diameter should be considered, for screws without pre-drilling the thread diameter (= core diameter d_2). For drill hole diameter, see table 6.1. Core diameter as follows:

ETA 3.9

	A		B	C
1	Outer thread diameter d_1	[mm]	10.0	12.0
2	Core diameter d_2	[mm]	6.1	7.35

If screws with an outer thread diameter of ≥ 8 mm are used in load-bearing wood constructions, the solid wood, laminated timber, laminated veneer lumber and similarly glued materials have to consist of spruce, pine or fir wood.
This does not apply for screwing into pre-drilled components.

ETA 3.11

With components made of Douglas fir the minimum spacings have to be increased by 50 % in the grain direction.

ETA 3.11

For connections in load-bearing wood constructions at least two screws or threaded rods respectively must be used. This does not apply for reinforcements or other situations named in the national annexes of EN 1995-1-1, such as, for example, for the fastening of shutterings, battens (carrying and counter battens) and wind braces, also not for the attachment of rafters, purlins and similar elements on beam hangers and framing as well as crossbeams at framing woods when the component is connected with at least two wood screws.

For further regulations on the execution, see SPAX ETA section 4

ETA 3.11

NA; (NA.9)

6. Installation guidelines

6.2 Pre-drilling

ETA 3.11

Softwood: Wood components may be pre-drilled
For $d_1 \geq 8$ mm without pre-drilling only for the wood types spruce, pine and fir
Hardwood: Wood components **must** be pre-drilled

For pre-drilling of the wood component for SPAX, the preferred dimension of the drill diameter can be selected according to the following table.

Table 6.1 Preferred dimensions for the drill diameter for pre-drilled wood components depending on the SPAX nominal diameter

	A	B	C	D	E	F	G	H	I
1	SPAX®	Outer thread diameter d_1 [mm]							
2		4.0	4.5	5.0	6.0	8.0	10.0	12.0	16.0
3	Softwood	2.5	3.0	3.0	4.0	5.0	6.0	7.0	13.0
4	Hardwood	3.0	3.0	3.5	4.0	6.0	7.0	8.0	-

Further information is available in the SPAX wood construction report No. 6.
Hardwood is: Solid wood, laminated timber made of hardwood with a maximum characteristic density of 730 kg/m^3 or LVL made of hardwood with maximum characteristic density of 750 kg/m^3.

Pre-drill the through-holes for the screws in steel parts with a suitable diameter.

ETA 3.11

Pre-drill the through-holes for the screws in cement-bonded chipboards with $0.7 \cdot d_1$.

Pre-sink SPAX with flat countersunk head in steel and cement-bound chipboards with a suitable tool.

6.3 Minimum wood thickness t_{min} to prevent wood splitting

To prevent wood splitting, a minimum wood thickness t_{min} for components made of solid wood must be complied with for nail connections and screw connections without pre-drilling.

EC5; 8.3.1.2 (6)
NPD On 8.3.1.2 (7)

If the minimum spacings correspond to the specifications from EC5; Tab. 8.2 (see table 6.3; C-E), the minimum wood thicknesses must be as follows:

Softwood

$$t_{min} = \max\{14 \cdot d_1; (13 \cdot d_1 - 30) \cdot \frac{\rho_k}{200}\}$$

EC5; Eq. (8.19)

Pine

$$t_{min} = \max\{\ 7 \cdot d_1; (13 \cdot d_1 - 30) \cdot \frac{\rho_k}{400}\}$$

EC5; Eq. (8.18)

Because SPAX with point with 4CUT or CUT point reduce the risk of wood splitting significantly, reduced minimum wood thicknesses may be observed.

ETA 3.11

For additional specifications see Tab. 6.3 b.

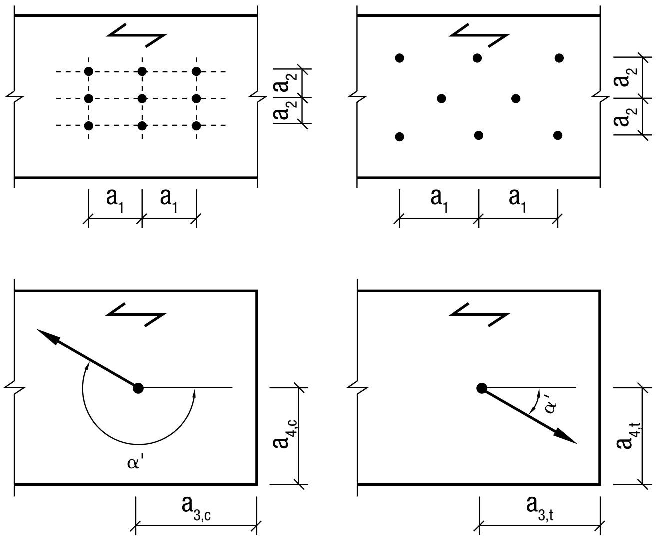
The requirement of a minimum wood thickness does not apply for pre-drilled wood components.

6. Installation guidelines

6.4 Minimum spacings

Table 6.2 Designation of the minimum spacings according to ETA for SPAX and according to EC5

EC5; Figure 8.7
SPAX ETA

	A	B
1		EC5 or SPAX
2		
3	Parallel to grain direction between each other 0° ≤ α' ≤ 360°	a_1
4	Perpendicular to grain direction between each other 0° ≤ α' ≤ 360°	a_2
5	Loaded end grain -90° ≤ α' ≤ 90°	$a_{3,t}$
6	Unloaded end grain 90° ≤ α' ≤ 270°	$a_{3,c}$
7	Loaded edge 0° ≤ α' ≤ 180°	$a_{4,t}$
8	Unloaded edge 180° ≤ α' ≤ 360°	$a_{4,c}$

6. Installation guidelines

6.4 Minimum spacings

Table 6.3 a Minimum spacings for shear force as well as combined loads for wood to wood connections according to EC5

	A	B	C	D	E
1	SPAX®		Shear forces or withdrawal forces or combined loads		
2			Spacings according to EC5; Tab. 8.2		
3			$A_{min} < 40 \cdot d_1^2$		Without minimum wood thickness being required, because pre-drilled.
4			Alternative minimum spacings for SPAX $d_1 \leq 6$ mm: see table 6.3b C2-C5 or D2-D5, for SPAX $d_1 \geq 8$ mm: see table 6.3b E2-E5		
5			Minimum wood thickness: see SPAX ETA-12/0114; 3.11 [b]		
6			Not pre-drilled		Pre-drilled
7			$\rho k \leq 420$ kg/m³	420 kg/m³ $< \rho k < 500$ kg/m³	
8	a_1	Parallel to grain direction $0° \leq \alpha' \leq 360°$	$d_1 < 5$ mm: $(5 + 5 \lvert \cos \alpha' \rvert) \cdot d_1$	$(7 + 8 \lvert \cos \alpha' \rvert) \cdot d_1$	$(4 + \lvert \cos \alpha' \rvert) \cdot d_1$
9			$d_1 \geq 5$ mm: $(5 + 7 \lvert \cos \alpha' \rvert) \cdot d_1$		
10	a_2	Perpendicular to grain direction $0° \leq \alpha' \leq 360°$	$5 \cdot d_1$	$7 \cdot d_1$	$(3 + \lvert \sin \alpha' \rvert) \cdot d_1$
11	$a_{3,t}$	Loaded end grain $-90° \leq \alpha' \leq 90°$	$(10 + 5 \cos \alpha') \cdot d_1$	$(15 + 5 \cos \alpha') \cdot d_1$	$(7 + 5 \cos \alpha') \cdot d_1$
12	$a_{3,c}$	Unloaded end grain $90° \leq \alpha' \leq 270°$	$10 \cdot d_1$	$15 \cdot d_1$	$7 \cdot d_1$
13	$a_{4,t}$	Loaded edge $0° \leq \alpha' \leq 180°$	$d_1 < 5$ mm: $(5 + 2 \cdot \sin \alpha') \cdot d_1$	$d_1 < 5$ mm: $(7 + 2 \cdot \sin \alpha') \cdot d_1$	$d_1 < 5$ mm: $(3 + 2 \cdot \sin \alpha') \cdot d_1$
14			$d_1 \geq 5$ mm: $(5 + 5 \cdot \sin \alpha') \cdot d_1$	$d_1 \geq 5$ mm: $(7 + 5 \cdot \sin \alpha') \cdot d_1$	$d_1 \geq 5$ mm: $(3 + 4 \cdot \sin \alpha') \cdot d_1$
15	$a_{4,c}$	Unloaded edge $180° \leq \alpha' \leq 360°$	$5 \cdot d_1$ [a]	$7 \cdot d_1$ [a]	$3 \cdot d_1$

α' = Angle between force direction and wood grain direction

A_{min} = Minimum wood cross-section area of the wood components to be connected

With Douglas fir the minimum spacings have to be increased by 50 % in the grain direction.

[a] The following applies for SPAX: If a_1 and $a_{3,t}$ and $a_{3,c} \geq 25 \cdot d_1$ are observed, $a_{4,c} = 3 \cdot d_1$ may be assumed

[b] If not defined otherwise, the minimum thickness for components without pre-drilling amounts to $t = 24$ mm for screws with an outer thread diameter of $d_1 < 8$ mm, $t = 30$ mm for screws with an outer thread diameter of $d_1 = 8$ mm, $t = 40$ mm for screws with an outer thread diameter of $d_1 = 10$ mm and $t = 80$ mm for screws with an outer thread diameter of $d_1 = 12$ mm.

The spacing to the loaded and unloaded edge has to amount to at least $15 \cdot d_1$ for screws in non-drilled components with an outer thread diameter of $d_1 \geq 8$ mm and a wood thickness of $t < 5 \cdot d_1$.

The minimum spacing of an unloaded edge transversely to the grain direction can also be reduced for a wood thickness of $t < 5 \cdot d_1$ to $3 \cdot d_1$, in as far as the spacing in the grain direction and to the end grain amounts to at least $25 \cdot d_1$.

6.4 Minimum spacings

Table 6.3 b Minimum spacings for shear force as well as combined loads for wood to wood connections according to SPAX ETA 3.11

	A	B	C	D	E	F
1			Shear forces or withdrawal forces or combined loads			Withdrawal forces
2			Amin ≥ 40 · d_1^2			
3			SPAX $d_1 \leq 6$ mm		SPAX $d_1 \geq 8$ mm	SPAX $d_1 \leq 12$ mm
4			4CUT point	CUT point	Point with 4CUT or CUT point	Point with 4CUT or CUT point [b]
5			$t_{min} = \max \begin{cases} 6 \cdot d_1 \\ 20 \text{ mm} \end{cases}$ [d]	$t_{min} = \max \begin{cases} 5 \cdot d_1 \\ 20 \text{ mm} \end{cases}$ [d]	$t_{min} = \max$ [d]	$t_{min} = 12 \cdot d_1$ [d] For LVL: $t_{min} = 6 \cdot d_1$
6			Not pre-drilled	Not pre-drilled	Not pre-drilled	Not pre-drilled
7	a_1	Parallel to grain direction $0° \leq \alpha' \leq 360°$	$5 \cdot d_1$			$5 \cdot d_1$
8	a_2	Perpendicular to grain direction $0° \leq \alpha' \leq 360°$	$(3 + \lvert \sin \alpha' \rvert) \cdot d_1$			$5 \cdot d_1$ or $2.5 \cdot d_1$ (if $a_1 \cdot a_2 = 25 \cdot d_1^2$)
9	$a_{3,t}$	Loaded end grain $-90° \leq \alpha' \leq 90°$	$12 \cdot d_1$			[c]
10	$a_{3,c}$	Unloaded end grain $90° \leq \alpha' \leq 270°$	$12 \cdot d_1$			$5 \cdot d_1$
11	$a_{4,t}$	Loaded edge $0° \leq \alpha' \leq 180°$	$d_1 < 5$ mm: $(3 + 2 \cdot \sin \alpha') \cdot d_1$			[c]
			$d_1 \geq 5$ mm: $(3 + 4 \cdot \sin \alpha') \cdot d_1$			
12	$a_{4,c}$	Unloaded edge $180° \leq \alpha' \leq 360°$	$3 \cdot d_1$			$3 \cdot d_1$

A_{min} = Minimum wood cross-section area of the wood components to be connected

With Douglas fir the minimum spacings have to be increased by 50 % in the grain direction.

[b] No special point shapes required for LVL

[c] For SPAX screws planned to be only subjected to withdrawal force all edges have to be considered as unloaded

[d] The specifications for minimum wood thickness do not apply for pre-drilled wood components

6. Installation guidelines

Minimum spacings of SPAX screws loaded in screw axis

ETA Annex B

For screws located crosswise which are only axially loaded, the axis spacing a_2 may be assumed to be as follows:

$$a_2 \geq \begin{cases} 1{,}5 \cdot d_1 & \text{with } 70° < \alpha_k \leq 90° \\ 2{,}5 \cdot \left(1 - \frac{\alpha_k}{180°}\right) \cdot d_1 & \text{with } 30° \leq \alpha_k \leq 70° \end{cases}$$

α_k = Intersection angle of the screws

For $\alpha_k < 30°$ see Table 6.3 b Cell F8.

Between screws located in parallel of adjacent crosswise screws the minimum spacings a_1 and a_2 have to be observed.

Diagram 6.1 Minimum spacing a_2 depending on α_k, the intersection angle of the screws

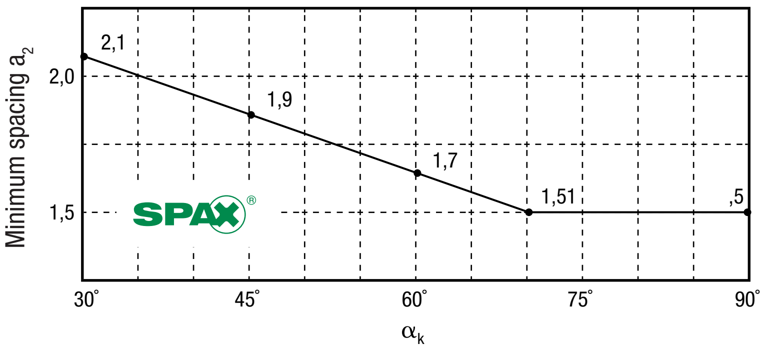
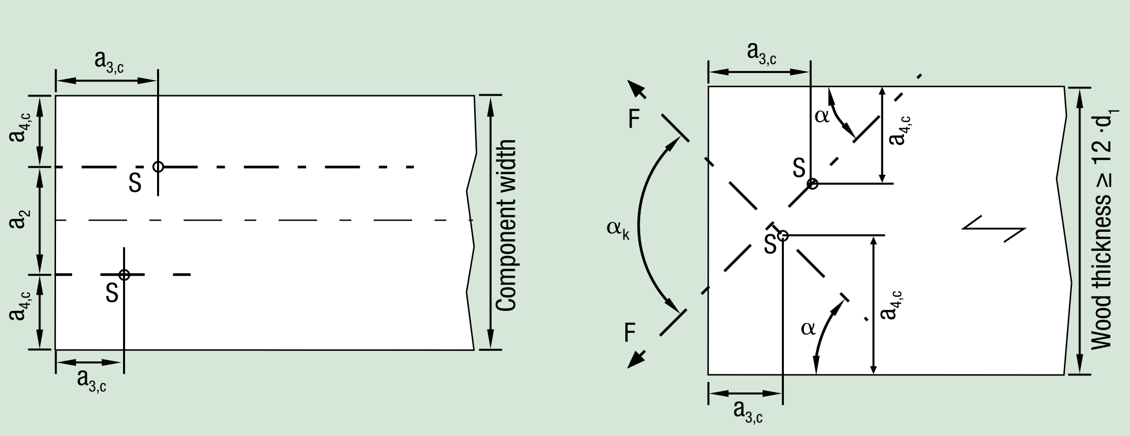


Figure 6.1 Crosswise location (as an example for 1 pair of screws)



Top view

View

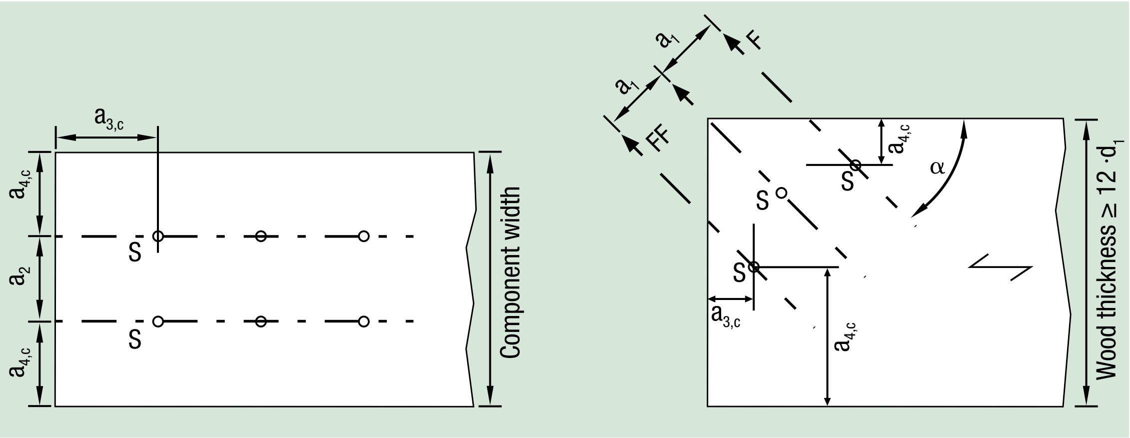
S = Centre of gravity of the screw part screwed-in the wood.
For pre-drilled wood components the requirement of wood thickness ≥ 12 · d_1 does not apply.

6. Installation guidelines

Minimum spacings of SPAX screws with axial loading

ETA Annex B

Figure 6.2 Single-direction location (as an example for 3 pairs of screws)



Top view

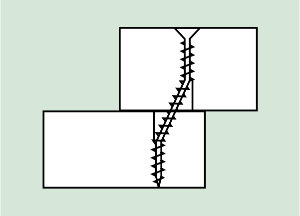
View

S = Centre of gravity of the screw part screwed-in the wood.
For pre-drilled wood components the requirement of wood thickness ≥ 12 · d_1 does not apply.

7. Dimensioning - Shear forces and withdrawal forces

SPAX dimensioning sheet

Shear forces



Failure case (f)

$$F_{v,Rk} = \underbrace{1{,}15\sqrt{\frac{2\beta}{1+\beta}}\sqrt{2M_{y,Rk}\,f_{h,1,k}\,d_1}}_{\text{Load-bearing shear forces}} + \underbrace{\frac{F_{ax,\alpha,Rk}}{4}}_{\Delta R_k \text{ Rope effect}} \qquad (f)$$

Observe minimum embedding according to Tab. 7.1 and following!

Tab. 7.2.1 [N] ΔR_k see Tab. 7.3.1 f. [N]

$F_{v,Rk} = +$ ☐ ☐ = ☐

[N] [N]

$F_{v,Rd} = +$ ☐ $\cdot \dfrac{k_{mod}}{\gamma_M}$ $\dfrac{☐}{1{,}3}$ = ☐

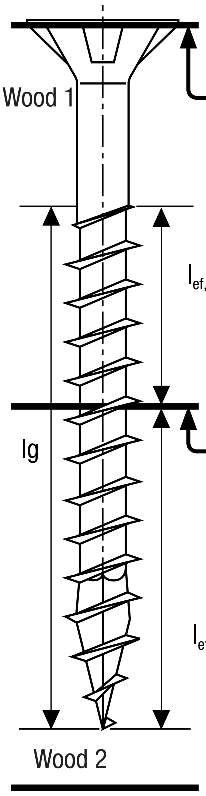
$F_{v,Rk}$ = Characteristic value of the load-bearing shear forces

$F_{v,Rd}$ = Design value of the load-bearing capacity shear forces

* If head pull-through does not become decisive, calculate the rope effect in the withdrawal area.

$\Delta R_k = \min \{F_{v,Rk}\ ;\ 0.25 \cdot f_{ax,\alpha,Rk}\}$

Withdrawal forces



Tab. 7.16.1 ☐ $\cdot \dfrac{k_{mod}}{\gamma_M}$ $\dfrac{☐}{1.3}$ = ☐ [N]

Tab.7.14 ☐ · $l_{ef,k}$ [mm] ☐ · Diagr. 7.14a ☐ $\cdot \dfrac{k_{mod}}{\gamma_M}$ $\dfrac{☐}{1.3}$ = ☐ [N]

max = ☐ [N]

Tab. 7.15 ☐ $\cdot \dfrac{1}{\gamma_M}$ $\dfrac{1}{1.3}$ = ☐ [N] = ☐ [N]

Tab. 7.14 ☐ · l_{ef} [mm] ☐ · Diagr. 7.14a ☐ $\cdot \dfrac{k_{mod}}{\gamma_M}$ $\dfrac{☐}{1.3}$ = ☐ [N]

$F_{ax,\alpha,Rd}$ = [N]

min = ☐

Rope effect $\Delta R_k = \dfrac{\text{decisive } F_{ax,\alpha,Rk}}{4} = \dfrac{☐}{4} =$ ☐ [N] [N] (according to EC5 8.2)

$F_{ax,\alpha,Rk}$ = Characteristic value of the load-bearing capacity withdrawal force

$F_{ax,\alpha,Rd}$ = Design value of the load-bearing capacity withdrawal force

$\left.\begin{matrix} k_{mod} \\ \gamma_M \end{matrix}\right\}$ According to EC5 or decisive national annex

7. Shear forces wood to wood connection

Minimum wood thickness or minimum penetration depth

Table 7.1.1 Minimum wood thickness $t_{1,req}$ or minimum penetration depth $t_{2,req}$ for wood to wood connections of non-pre-drilled components with woods of the same bulk density $\beta = 1$, $t_{1,req} = t_{2,req}$ [mm] applies for SPAX made of carbon steel, not pre-drilled

NA; Eq. (NA.110)

	A	B	C	D	E	F	G	H	I	J
1	SPAX®			Outer thread diameter d_1 [mm]						
2	Strength class		ρ_k [kg/m^3]	4.0	4.5	5.0	6.0	8.0	10.0	12.0
3	C14		290	28.5	31.9	35.2	41.9	55.1	68.1	81.0
4	C16		310	27.6	30.8	34.1	40.5	53.3	65.8	78.3
5	C18		320	27.1	30.4	33.5	39.9	52.4	64.8	77.1
6	C20		330	26.7	29.9	33.0	39.3	51.6	63.8	75.9
7	C22	GL20h	340	26.3	29.4	32.5	38.7	50.9	62.9	74.8
8	C24		350	25.9	29.0	32.1	38.1	50.1	62.0	73.7
9		GL20c GL22c	355	25.8	28.8	31.9	37.9	49.8	61.5	73.2
10	C27		360	25.6	28.6	31.6	37.6	49.4	61.1	72.7
11		GL24c	365	25.4	28.4	31.4	37.4	49.1	60.7	72.2
12		GL22h	370	25.2	28.2	31.2	37.1	48.8	60.3	71.7
13	C30		380	24.9	27.9	30.8	36.6	48.1	59.5	70.7
14		GL26c GL24h	385	24.7	27.7	30.6	36.4	47.8	59.1	70.3
15	C35	GL28c GL30c	390	24.6	27.5	30.4	36.1	47.5	58.7	69.8
16	C40	GL32c	400	24.3	27.1	30.0	35.7	46.9	58.0	68.9
17		GL26h	405	24.1	27.0	29.8	35.5	46.6	57.6	68.5
18	C45		410	24.0	26.8	29.6	35.2	46.3	57.3	68.1
19		GL28h	425	23.5	26.3	29.1	34.6	45.5	56.2	66.9
20	C50	GL30h	430	23.4	26.2	28.9	34.4	45.2	55.9	66.5
21		GL32h	440	23.1	25.9	28.6	34.0	44.7	55.3	65.7
22		LVL	480	22.2	24.8	27.4	32.6	42.8	52.9	62.9

Table 7.1.2 Minimum wood thickness $t_{1,req}$ or minimum penetration depth $t_{2,req}$ for wood to wood connections of pre-drilled components with hardwoods of the same bulk density $\beta = 1$, $t_{1,req} = t_{2,req}$ [mm] applies, valid for SPAX made of carbon steel, pre-drilled

	A	B	C	D	E	F	G	H	I	J
1	SPAX®			Outer thread diameter d_1 [mm]						
2	Strength class		ρ_k [kg/m^3]	4.0	4.5	5.0	6.0	8.0	10.0	12.0
3	D24		485	18.3	20.1	22.0	25.5	32.5	39.3	46.0
4	D30		530	17.5	19.3	21.0	24.4	31.1	37.6	44.0
5	D40		550	17.2	18.9	20.6	24.0	30.5	36.9	43.2
6	D50		620	16.2	17.8	19.4	22.6	28.7	34.7	40.7
7	D60		700	15.2	16.8	18.3	21.3	27.1	32.7	38.3
8		Beech LVL	730	14.9	16.4	17.9	20.8	26.5	32.0	37.5

The associated correction factors, for pre-drilling and stainless steel, as well as the penetration angle a, are specified on the next page.

7. Shear forces wood to wood connection

Minimum wood thickness or minimum penetration depth

Table 7.1 a Correction factors for respective SPAX diameter

	A	B	C	D	E	F	G	H
1	SPAX	Outer thread diameter d_1 [mm]						
2		4.0	4.5	5.0	6.0	8.0	10.0	12.0
3	Stainless steel	0.816	0.816	0.816	0.816	0.816	0.816	0.816
4	Pre-drilled	0.829	0.817	0.806	0.788	0.763	0.746	0.734

If the wood thicknesses t_1 or t_2 are lower than the minimum thicknesses $t_{1,req}$ or $t_{2,req}$, the characteristic value of the load-bearing capacity R_k may be determined by multiplying the value R_k with the smaller of the ratio values $t_1/t_{1,req}$ and $t_2/t_{2,req}$.

NA; 8.2.4 (NA.2)

Diagram 7.1 b Correction factor for the conversion of the minimum wood thickness or minimum penetration depth t_{req} depending on penetration angle α for $\beta = 1$

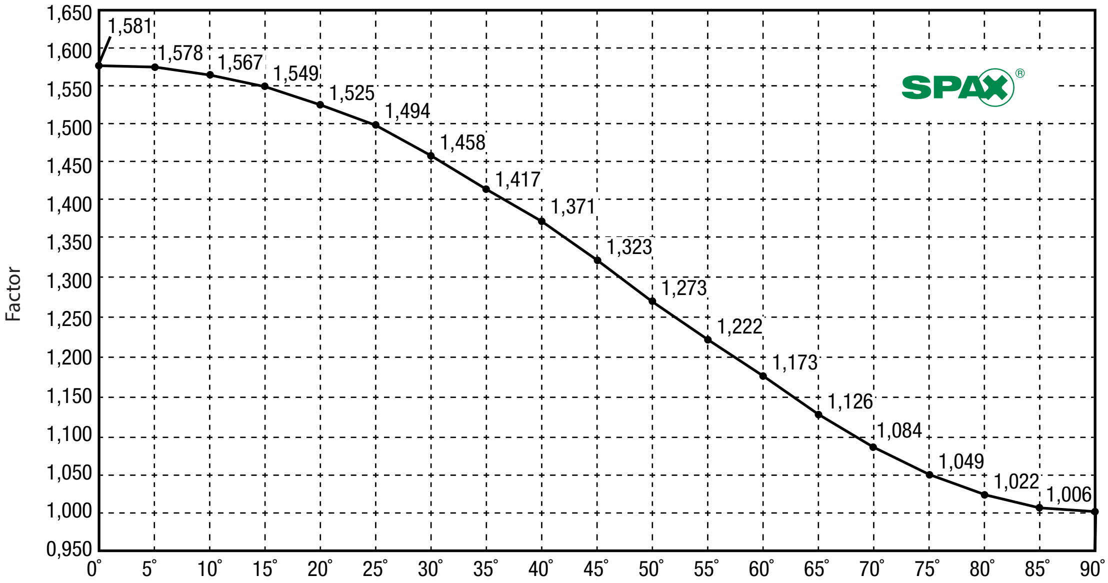


Diagram corresponds to: $\sqrt{2,5 \cdot \cos^2 \alpha + \sin^2 \alpha}$

Wood-based products to wood connections and steel plate to wood connections are not specified in a table. Please use the SPAX design software to this purpose at https://designsoftware.spax.com (see page 3).

7. Shear forces wood to wood connection

Load-bearing capacity

EC5; Eq. (8.6(f))

Table 7.2.1 Characteristic values $F_{v,Rk}$ of the load-bearing capacity of single shear wood to wood connections of not pre-drilled components with woods of the same bulk density per shear plane [N] for $\beta = 1$, valid for SPAX made of carbon steel, not pre-drilled

	A	B	C	D	E	F	G	H	I	J
1	SPAX®			Outer thread diameter d_1 [mm]						
2	Strength class		ρ_k [kg/m³]	4.0	4.5	5.0	6.0	8.0	10.0	12.0
3	C14		290	741	900	1071	1447	2326	3361	4540
4	C16		310	766	931	1107	1496	2404	3475	4694
5	C18		320	778	945	1125	1520	2443	3530	4769
6	C20		330	790	960	1142	1543	2481	3585	4843
7	C22	GL20h	340	802	974	1160	1566	2518	3639	4916
8	C24		350	814	989	1176	1589	2555	3692	4988
9		GL20c GL22c	355	820	996	1185	1601	2573	3718	5023
10	C27		360	826	1003	1193	1612	2591	3744	5059
11		GL24c	365	831	1010	1201	1623	2609	3770	5094
12		GL22h	370	837	1017	1210	1634	2627	3796	5129
13	C30		380	848	1030	1226	1656	2662	3847	5197
14		GL26c GL24h	385	854	1037	1234	1667	2680	3872	5231
15	C35	GL28c GL30c	390	859	1044	1242	1678	2697	3897	5265
16	C40	GL32c	400	870	1057	1258	1699	2731	3947	5332
17		GL26h	405	876	1064	1266	1710	2748	3972	5366
18	C45		410	881	1070	1273	1720	2765	3996	5399
19		GL28h	425	897	1090	1296	1751	2815	4069	5496
20	C50	GL30h	430	902	1096	1304	1762	2832	4092	5529
21		GL32h	440	913	1109	1319	1782	2865	4140	5593
22		LVL	480	953	1158	1378	1861	2992	4324	5841

Table 7.2.2 Characteristic values $F_{v,Rk}$ of the load-bearing capacity of single shear wood to wood connections of pre-drilled components with hardwoods of the same bulk density per shear plane [N] for $\beta = 1$, valid for SPAX made of carbon steel, pre-drilled

	A	B	C	D	E	F	G	H	I	J
1	SPAX®			Outer thread diameter d_1 [mm]						
2	Strength class		ρ_k [kg/m³]	4.0	4.5	5.0	6.0	8.0	10.0	12.0
3	D24		485	1156	1425	1718	2373	3941	5824	7996
4	D30		530	1208	1490	1796	2481	4119	6088	8359
5	D40		550	1231	1518	1830	2527	4196	6202	8515
6	D50		620	1307	1611	1943	2683	4455	6585	9041
7	D60		700	1389	1712	2064	2851	4734	6997	9606
8		Beech LVL	730	1418	1749	2108	2912	4835	7145	9810

The associated correction factors, for pre-drilling and stainless steel, as well as the penetration angle α, are specified on the next page.

7. Shear forces wood to wood connection

Load-bearing capacity

Table 7.2 a Correction factors for SPAX further materials

	A	B	C	D	E	F	G	H
1	SPAX	Outer thread diameter d1 [mm]						
2		4.0	4.5	5.0	6.0	8.0	10.0	12.0
3	Stainless steel	0.816	0.816	0.816	0.816	0.816	0.816	0.816
4	Pre-drilled	1.206	1.225	1.241	1.268	1.310	1.340	1.362

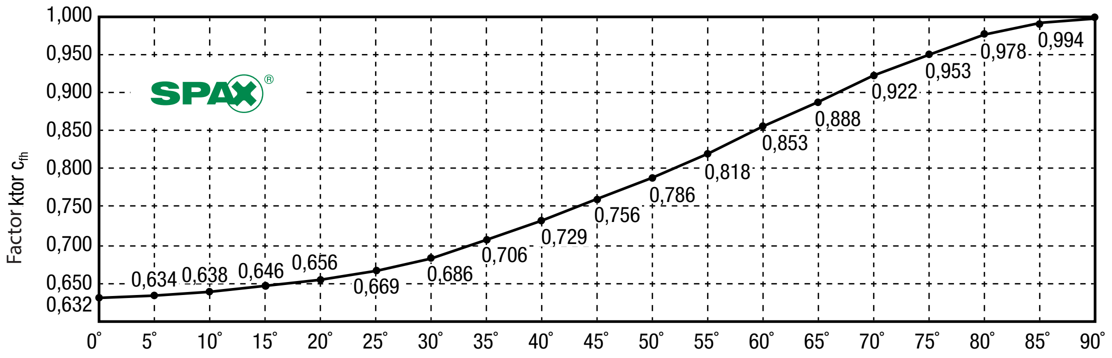
EC5; 8.2.2 (2)

ΔR_k - for single shear connections the characteristic value $F_{v,Rk}$ of the load-bearing capacity is increased by a share of ΔR_k.

Rope effect $\Delta R_k = \min\{F_{ax,\alpha,Rk}/4 ; F_{v,Rk}\}$

Further specifications on the value ΔR_k are available on the following pages in Tables 7.3 and following!

Diagram 7.2 b Correction of the characteristic load-bearing capacity $F_{v,Rk}$ depending on the penetration angle α



ETA 3.9

Diagram corresponds to: $\sqrt{\frac{1}{^2\alpha + \sin^2\alpha}}$

2.5 · cos

$\beta = \frac{c_{fh} \cdot f_{h,2,k}}{c_{fh} \cdot f_{h,1,k}}$ =>Correction factor for $F_{v,Rk}$= $\sqrt{\frac{2\beta}{1+\beta}}$

Wood-based products to wood connections and steel plate to wood connections are not specified in a table. Please use the SPAX design software to this purpose at https://designsoftware.spax.com (see page 3).

7. Shear forces wood to wood connection

Load-bearing capacity

Table 7.3.1 Characteristic values $\Delta R_k = 0.25 \times F_{ax,\alpha,Rk}$ [N] for flat countersunk head, raised countersunk head with full or partial thread, if head pull-through failure is decisive

	A	B	C	D	E	F	G	H	I	J
1	SPAX®			Outer thread diameter d_1 [mm]						
2				4.0	4.5	5.0	6.0	8.0	10.0	12.0
3				Flat countersunk head, head diameter d_h [mm]						
4	Strength class		ρ_k [kg/m³]	8.0	8.8	9.7	11.6	15.1	18.6	22.6
5	C16		310	276	320	369	470	616	823	1122
6	C18		320	283	328	379	482	631	844	1151
7	C20		330	290	336	388	494	647	865	1179
8	C22	GL20h	340	297	344	398	506	663	886	1208
9	C24		350	304	352	407	518	678	906	1236
10		GL20c GL22c	355	307	356	412	524	686	917	1250
11	C27		360	311	360	416	530	694	927	1264
12		GL24c	365	314	364	421	536	701	937	1278
13		GL22h	370	318	368	425	542	709	948	1292
14	C30		380	325	376	435	553	724	968	1320
15		GL26c GL24h	385	328	380	439	559	732	978	1334
16	C35	GL28c GL30c	390	331	384	444	565	740	988	1348
17	C40	GL32c	400	338	392	453	576	755	1009	1375
18		GL26h	405	342	396	457	582	762	1019	1389
19	C45		410	345	400	462	588	770	1029	1403
20		GL28h	425	355	412	475	605	792	1059	1444
21	C50	GL30h	430	358	415	480	611	800	1069	1457
22		GL32h	440	365	423	489	622	815	1089	1484
23		LVL	480	391	454	524	667	873	1167	1591
24	Pre-drilled hardwood									
25	D24		485	395	457	528	673	881	1177	1605
26	D30		530	424	491	567	722	945	1263	1723
27	D40		550	436	506	584	744	974	1301	1774
28	D50		620	480	557	643	819	1072	1432	1953
29	D60		700	529	613	709	902	1181	1578	2152
30		Beech LVL	730	547	634	733	933	1221	1632	2226
31	Required in wood of same strength class $l_{ef} \geq$ [mm]			**22**	**22**	**23**	**29**	28	32	37
32	However, at least $l_{ef} \geq 4 \cdot d_1$			16	18	20	24	**32**	**40**	**48**

Tab. 7.3.1 a Correction factor

	A	B	C	D	E	F	G	H
1	Outer thread diameter d_1 [mm]	4.0	4.5	5.0	6.0	8.0	10.0	12.0
2	For $t_1 \geq 3 \cdot d_h$ [mm]	24.0	26.4	29.1	34.8	45.3	55.8	67.8
3	Increase by factor	**1.3**						

7. Shear forces wood to wood connection

Load-bearing capacity

Table 7.3.2 Characteristic values $\Delta R_k = 0.25 \times F_{ax,\alpha,Rk}$ [N] for pan head with full or partial thread, if head pull-through failure is decisive

	A	B	C	D	E	F	G
1	SPAX®			Outer thread diameter d_1 [mm]			
2				4.0	4.5	5.0	6.0
3				Pan head, head diameter d_h [mm]			
4	Strength class		ρ_k [kg/m^3]	8.0	9.0	9.9	11.9
5	C16		310	305	368	425	549
6	C18		320	313	377	436	564
7	C20		330	321	386	446	578
8	C22	GL20h	340	328	396	457	592
9	C24		350	336	405	468	605
10		GL20c GL22c	355	340	410	473	612
11	C27		360	344	414	479	619
12		GL24c	365	347	419	484	626
13		GL22h	370	351	423	489	633
14	C30		380	359	433	500	647
15		GL26c GL24h	385	363	437	505	653
16	C35	GL28c GL30c	390	366	442	510	660
17	C40	GL32c	400	374	451	521	674
18		GL26h	405	378	455	526	680
19	C45		410	381	460	531	687
20		GL28h	425	392	473	547	707
21	C50	GL30h	430	396	478	552	714
22		GL32h	440	404	486	562	727
23		LVL	480	433	521	603	779
24	Pre-drilled hardwood						
25	D24		485	436	526	608	786
26	D30		530	468	564	652	844
27	D40		550	482	581	672	869
28	D50		620	531	640	739	957
29	D60		700	585	705	815	1054
30		Beech LVL	730	605	729	843	1090
31	Required in wood of same strength class $l_{ef} \geq$ [mm]			**24**	**26**	**27**	**34**
32	However, at least $l_{ef} \geq 4 \cdot d_1$			16	18	20	24

Tab. 7.3.2 a Correction factor

	A	B	C	D	E
1	Outer thread diameter d_1 [mm]	4.0	4.5	5.0	6.0
2	For $t_1 \geq 3 \cdot d_h$ [mm]	24.0	27.0	29.7	35.7
3	Increase by factor	**1.3**			

You can also use the SPAX design software to calculate your projects at https://designsoftware.spax.com

7. Shear forces wood to wood connection

Load-bearing capacity

Table 7.3.3 Characteristic values $\Delta R_k = 0.25 \times F_{ax,\alpha,Rk}$ [N] for washer head with full or partial thread, if head pull-through failure is decisive

	A	B	C	D	E	F	G	H	I
1				Outer thread diameter d_1 [mm]					
2				4.0	4.5	5.0	6.0	8.0	10.0
3				Head diameter d_h [mm]					
4				Flange head			Washer head		
5	Strength class		ρ_k [kg/m³]	9.6	10.6	11.6	13.6	20.0	25.0
6	C14		290	385	445	504	613	1118	1546
7	C16		310	406	469	531	646	1180	1631
8	C18		320	416	481	545	663	1210	1673
9	C20		330	426	493	558	679	1240	1714
10	C22	GL20h	340	437	505	572	696	1270	1756
11	C24		350	447	517	585	712	1300	1797
12		GL20c GL22c	355	452	523	592	720	1315	1817
13	C27		360	457	529	599	728	1330	1838
14		GL24c	365	462	535	605	736	1344	1858
15		GL22h	370	467	540	612	744	1359	1879
16	C30		380	477	552	625	761	1388	1919
17		GL26c GL24h	385	482	558	632	769	1403	1939
18	C35	GL28c GL30c	390	487	564	638	776	1418	1959
19	C40	GL32c	400	497	575	651	792	1447	1999
20		GL26h	405	502	581	658	800	1461	2019
21	C45		410	507	587	664	808	1475	2039
22		GL28h	425	522	604	684	832	1518	2099
23	C50	GL30h	430	527	609	690	840	1533	2119
24		GL32h	440	537	621	703	855	1561	2158
25		LVL	480	575	665	754	917	1674	2313
26	Pre-drilled hardwood								
27	D24		485	580	671	760	924	1688	2333
28	D30		530	623	720	816	992	1812	2504
29	D40		550	642	742	840	1022	1866	2580
30	D50		620	706	817	925	1125	2054	2839
31	D60		700	778	900	1019	1240	2263	3129
32		Beech LVL	730	805	931	1054	1282	2341	3235
33	Required in wood of same strength class $l_{ef} \geq$ [mm]			**32**	**33**	**33**	**40**	**54**	**63**
33	However, at least $l_{ef} \geq 4 \cdot d_1$			16	18	20	24	32	40

Tab. 7.3.3 a Increase factor

	A	B	C	D	E	F	H
1	Outer thread diameter d_1 [mm]	4.0	4.5	5.0	6.0	8.0	10.0
2	For $t_1 \geq 3 \cdot d_h$ [mm]	28.8	31.8	34.8	40.8	60.0	75.0
3	Increase by factor	**1.3**					

7. Shear forces wood to wood connection

Load-bearing capacity

Table 7.3.4 Characteristic values $\Delta R_k = 0{,}25 \times F_{ax,\alpha,Rk}$ [N] for countersunk head screws with full and partial thread and with rosette washer*, if head pull-through failure is decisive

*see Table 8.7

	A	B	C	D	E	F	G
1				Screw nominal diameter d_1 [mm]			
2				6.0	8.0	10.0	12.0
3				Rosette washer diameter Da [mm]			
4	Strength class		ρ_k [kg/m³]	18.0	25.0	32.0	40.0
5	C14		290	906	1546	1762	1762
6	C16		310	956	1631	1859	1859
7	C18		320	980	1673	1906	1906
8	C20		330	1005	1714	1954	1954
9	C22	GL20h	340	1029	1756	2001	2001
10	C24		350	1053	1797	2048	2048
11		GL 20c GL22c	355	1065	1817	2071	2071
12	C27		360	1077	1838	2095	2095
13		GL24c	365	1089	1858	2118	2118
14		GL22h	370	1101	1879	2141	2141
15	C30		380	1125	1919	2187	2187
16		GL26c GL24h	385	1136	1939	2210	2210
17	C35	GL28c GL30c	390	1148	1959	2233	2233
18	C40	GL32c	400	1172	1999	2279	2279
19		GL26h	405	1183	2019	2302	2302
20	C45		410	1195	2039	2324	2324
21		GL28h	425	1230	2099	2392	2392
22	C50	GL30h	430	1242	2119	2415	2415
23		GL32h	440	1265	2158	2459	2459
24		LVL	480	1356	2313	2637	2637
25	Pre-drilled hardwood						
26	D24		485	1367	2333	2659	2659
27	D30		530	1468	2504	2854	2854
28	D40		550	1512	2580	2940	2940
29	D50		620	1664	2839	3236	3236
30	D60		700	1833	3129	3566	3566
31		Beech LVL	730	1896	3235	3688	3688
32	Required in wood of same strength class $l_{ef} \geq$ [mm]			**59**	**75**	**71**	**62**
33	However, at least $l_{ef} \geq 4 \cdot d_1$			24	32	40	48

Rosette washers with a diameter Da > 32 mm are only calculated with a diameter of Da = 32 mm.

Tab. 7.3.4 a Increase factor

	A	B	C	D	E
1	Outer thread diameter d_1 [mm]	6.0	8.0	10.0	12.0
2	For $t_1 \geq 3 \cdot d_h$ [mm]	54.0	75.0	96.0	120.0
3	Increase by factor	**1.3**			

7. Shear forces sheet metal to wood connection

Outside thin steel plates

Steel plates are to be considered as thin if the steel plate thickness t_s is not greater than half the screw diameter d_1.
Steel plate = thin, if $t_s \leq 0.5 \cdot d_1$

EC5; 8.2.3 (1)

Minimum wood thickness or minimum penetration depth
According to Tables 7.1.1; 7.1.2; 7.1 a and Diagram 7.1 b

(NA. 119)

Load-bearing capacity
According to Tables 7.2.1; 7.2.2; 7.2 a and Diagram 7.2 b

(NA. 117)

Outside thick steel plates

Steel plates are to be considered as thick if the steel plate thickness t_s is at least equal to the screw diameter d_1.
Steel plate = thick, if $t_s \geq d_1$

EC5; 8.2.3 (1)

Minimum wood thickness or minimum penetration depth

According to Tables 7.1.1; 7.1.2; 7.1 a and Diagram 7.1 b
The values in the table must be increased by the factor **$4/(2+\sqrt{2}) = 1.172$.**

(NA. 116)

Load-bearing capacity
According to Tables 7.2.1; 7.2.2; 7.2 a and Diagram 7.2 b
The values in the table must be increased by the **factor $\sqrt{2} = 1.414$.**

(NA. 115)

For steel plate thicknesses $0.5 \cdot d_1 < t_s < d_1$ the characteristic values of the load-bearing capacity R_k must be interpolated linearly. As a simplification in this case, the minimum penetration depth t_{req} may be interpolated linearly.

NA; 8.2.5 (NA.3)

If the penetration depth t_2 is lower than the minimum penetration depth $t_{2,req}$, the characteristic value of the load-bearing capacity R_k may be determined by multiplying the value R_k with the ratio value $t_2/t_{2,req}$.

NA; 8.2.5 (NA.4)

Minimum spacings for steel plate to wood connections
As minimum spacings to each other (a_1 and a_2) the values according to table 6.3 multiplied with a factor of 0.7 apply.

EC5; 8.3.1.4 (1)

7. Withdrawal forces

Characteristic value of withdrawal resistance of the threaded part $F_{ax,\alpha,Rk}$

Table 7.14 Characteristic values $F_{ax,\alpha,Rk}$ of the load-bearing capacity with α = 90° penetration angle between screw axis and wood grain direction [N per mm effective thread length l_{ef}], valid for SPAX made of carbon steel and stainless steel

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	A	B	C	E	F	G	H	I	J	K
1	SPAX®			Outer thread diameter d_1 [mm]						
2	Strength class		ρ_k [kg/m³]	4.0	4.5	5.0	6.0	8.0	10.0	12.0
3	C16		310	50.8	57.2	63.5	65.3	87.1	104.4	119.8
4	C18		320	52.1	58.6	65.2	67.0	89.4	107.0	122.9
5	C20		330	53.4	60.1	66.8	68.7	91.6	109.7	125.9
6	C22	GL20h	340	54.7	61.6	68.4	70.3	93.8	112.4	129.0
7	C24		350	56.0	63.0	70.0	72.0	96.0	115.0	132.0
8		GL20c GL22c	355	56.6	63.7	70.8	72.8	97.1	116.3	133.5
9	C27		360	57.3	64.4	71.6	73.6	98.2	117.6	135.0
10		GL24c	365	57.9	65.2	72.4	74.5	99.3	118.9	136.5
11		GL22h	370	58.5	65.9	73.2	75.3	100.4	120.2	138.0
12	C30		380	59.8	67.3	74.8	76.9	102.5	122.8	141.0
13		GL26c GL24h	385	60.4	68.0	75.5	77.7	103.6	124.1	142.5
14	C35	GL28c GL30c	390	61.1	68.7	76.3	78.5	104.7	125.4	143.9
15	C40	GL32c	400	62.3	70.1	77.9	80.1	106.8	128.0	146.9
16		GL26h	405	62.9	70.8	78.7	80.9	107.9	129.2	148.3
17	C45		410	63.6	71.5	79.4	81.7	109.0	130.5	149.8
18		GL28h	425	65.4	73.6	81.8	84.1	112.1	134.3	154.2
19	C50	GL30h	430	66.0	74.3	82.5	84.9	113.2	135.6	155.6
20		GL32h	440	67.3	75.7	84.1	86.5	115.3	138.1	158.5
21		LVL	480	72.1	81.1	90.1	92.7	123.6	148.1	169.9
22	Pre-drilled hardwood									
23	D24		485	72.7	81.8	90.9	93.5	124.6	149.3	171.4
24	D30		530	78.0	87.8	97.6	100.3	133.8	160.3	184.0
25	D40		550	80.4	90.4	100.5	103.4	137.8	165.1	189.5
26	D50		620	88.5	99.5	110.6	113.8	151.7	181.7	208.6
27	D60		700	97.5	109.7	121.9	125.4	167.1	200.2	229.8
28		Beech LVL	730	100.8	113.4	126.0	129.6	172.9	207.1	237.7

Diagram 7.14. a Factor for the conversion depending on the penetration angle α

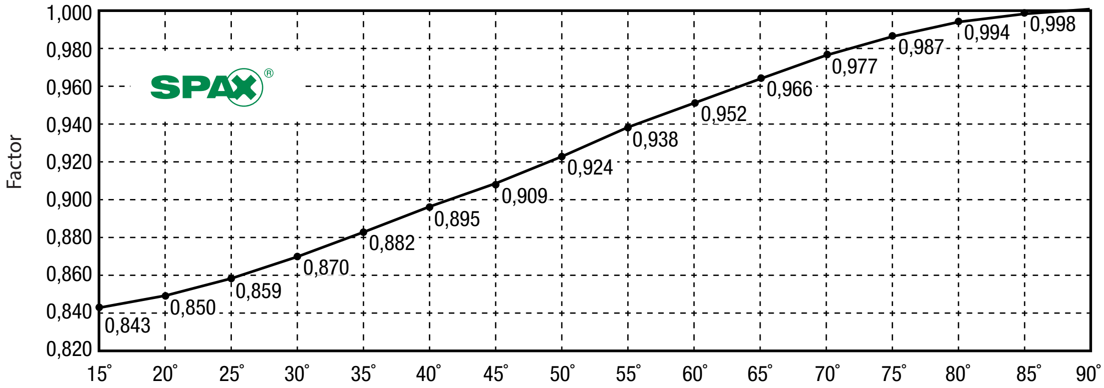


Diagram corresponds to: $\dfrac{1}{1.2 \cdot \cos^2\alpha + \sin^2\alpha}$

ETA 3.9

7. Withdrawal forces

Characteristic value $f_{tens,k}$ of the tensile capacity (steel)

ETA 3.1

Table 7.15 Characteristic value and design values of the tensile capacity (steel) [N], valid for SPAX made of carbon steel and stainless steel

	A	B	C	D	E	F	G	H	I
1	SPAX®		Outer thread diameter d_1 [mm]						
2			4.0	4.5	5.0	6.0	8.0	10.0	12.0
3	Carbon steel	$f_{tens,k}$	5000	6400	7900	11000	17000	28000	38000
4		$f_{tens,d}$	*3846*	*4923*	*6077*	*8462*	*13077*	*21538*	*29231*
5	Stainless steel	$f_{tens,k}$	3800	4200	4900	7100	13000	20000	28000
6		$f_{tens,d}$	*2923*	*3231*	*3769*	*5462*	*10000*	*15385*	*21538*

Partial safety factor $\gamma_M = 1.3$

The maximum possible load of a SPAX in the direction of the screw axis (withdrawal forces) is limited by the dimensioning value of the tensile capacity $f_{tens,d}$.

Wood-based products to wood connections and steel plate to wood connections are not specified in a table. Please use the SPAX design software to this purpose at https://designsoftware.spax.com (see page 3).

7. Withdrawal forces

Characteristic value $F_{ax,\alpha,Rhead,k,1}$ head pull-through

Table 7.16.1 Characteristic values $F_{ax,\alpha,Rhead,k,1}$ of the load-bearing capacity [N] for flat countersunk head and raised countersunk head

ETA 3.9

	A		C	D	E	F	G	H	I	J	K
1				Outer thread diameter d_1 [mm]							
2	SPAX®			4.0	4.5	5.0	6.0	8.0	10.0	12.0	
3				Flat countersunk head or raised countersunk head diameter d_h [mm]							
4				8.0	8.8	9.7	11.6	15.1	18.6	22.6	18.6
5	Strength class		ρ_k [kg/m³]							Partial thread	Full thread
6	C14		290	1046	1213	1400	1783	2334	3119	4254	3119
7	C16		310	1103	1279	1477	1880	2462	3290	4487	3290
8	C18		320	1132	1312	1515	1929	2526	3375	4602	3375
9	C20		330	1160	1345	1553	1977	2589	3459	4717	3459
10	C22	GL20h	340	1188	1377	1590	2025	2651	3543	4831	3543
11	C24		350	1216	1409	1628	2072	2713	3626	4944	3626
12		GL20c GL22c	355	1230	1425	1646	2096	2744	3667	5001	3667
13	C27		360	1244	1442	1665	2119	2775	3708	5057	3708
14		GL24c	365	1258	1458	1683	2143	2806	3749	5113	3749
15		GL22h	370	1271	1473	1702	2166	2837	3790	5169	3790
16	C30		380	1299	1505	1738	2213	2898	3872	5280	3872
17		GL26c GL24h	385	1312	1521	1757	2236	2928	3913	5336	3913
18	C35	GL28c GL30c	390	1326	1537	1775	2260	2959	3954	5391	3954
19	C40	GL32c	400	1353	1568	1811	2306	3019	4034	5502	4034
20		GL26h	405	1367	1584	1829	2329	3049	4075	5557	4075
21	C45		410	1380	1600	1847	2352	3079	4115	5611	4115
22		GL28h	425	1420	1646	1901	2420	3169	4235	5775	4235
23	C50	GL30h	430	1434	1662	1919	2443	3199	4275	5829	4275
24		GL32h	440	1460	1693	1955	2489	3258	4354	5937	4354
25		LVL	480	1566	1815	2096	2668	3493	4668	6365	4668
26	Pre-drilled hardwood										
27	D24		485	1579	1830	2113	2690	3522	4707	6418	4707
28	D30		530	1695	1964	2269	2888	3782	5053	6891	5053
29	D40		550	1746	2023	2337	2975	3895	5205	7098	5205
30	D50		620	1921	2227	2572	3274	4287	5729	7812	5729
31	D60		700	2117	2454	2834	3608	4724	6313	8608	6313
32		Beech LVL	730	2189	2538	2931	3731	4885	6528	8902	6528
33	Required in wood of same strength class $l_{ef} \geq$ [mm]			**22**	**22**	**23**	**29**	**28**	**32**	**37**	**27**
34	However, at least $l_{ef} \geq 4 \cdot d_1$			16	18	20	24	32	40	48	48

Tab. 7.16.1 b increase factor

	A	B	C	D	E	F	G	H	I
1	Outer thread diameter d_1 [mm]	4.0	4.5	5.0	6.0	8.0	10.0	12.0	
								Partial thread	Full thread
2	For $t_1 \geq 3 \cdot d_h$ [mm]	24.0	26.4	29.1	34.8	45.3	55.8	67.8	55.8
3	Increase by factor	**1.3**							

7. Withdrawal forces

Characteristic value $F_{ax,\alpha,Rhead,k,1}$ head pull-through

ETA 3.9

Table 7.16.2 Characteristic values $F_{ax,\alpha,Rhead,k,1}$ of the load-bearing capacity [N] for pan head

	A	B	C	D	E	F	G
1				Outer thread diameter d_1 [mm]			
2				4.0	4.5	5.0	6.0
3				Pan head, head diameter d_h [mm]			
4	Strength class		ρ_k [kg/m^3]	8.0	9.0	9.9	11.9
5	C14		290	1156	1394	1611	2083
6	C16		310	1220	1470	1699	2197
7	C18		320	1251	1508	1742	2254
8	C20		330	1282	1546	1786	2310
9	C22	GL20h	340	1313	1583	1829	2366
10	C24		350	1344	1620	1872	2422
11		GL20c GL22c	355	1359	1638	1893	2449
12	C27		360	1375	1657	1915	2477
13		GL24c	365	1390	1675	1936	2504
14		GL22h	370	1405	1694	1957	2532
15	C30		380	1435	1730	1999	2586
16		GL26c GL24h	385	1450	1748	2020	2613
17	C35	GL28c GL30c	390	1466	1766	2041	2641
18	C40	GL32c	400	1496	1803	2083	2695
19		GL26h	405	1510	1821	2104	2721
20	C45		410	1525	1839	2125	2748
21		GL28h	425	1570	1892	2187	2828
22	C50	GL30h	430	1585	1910	2207	2855
23		GL32h	440	1614	1945	2248	2908
24		LVL	480	1730	2086	2410	3118
25	Pre-drilled hardwood						
26	D24		485	1745	2103	2430	3144
27	D30		530	1873	2258	2609	3375
28	D40		550	1929	2326	2687	3476
29	D50		620	2124	2560	2958	3826
30	D60		700	2340	2821	3259	4216
31		Beech LVL	730	2420	2917	3371	4360
32	Required in wood of same strength class $l_{ef} \geq$ [mm]			**24**	**26**	**27**	**34**
33	However, at least $l_{ef} \geq 4 \cdot d_1$			16	18	20	24

Tab. 7.16.2 b Increase factor

	A	B	C	D	E
1	Outer thread diameter d_1 [mm]	4.0	4.5	5.0	6.0
2	For $t_1 \geq 3 \cdot d_h$ [mm]	24.0	27.0	29.7	35.7
3	Increase by factor	**1.3**			

7. Withdrawal forces

Characteristic value $F_{ax,\alpha,Rhead,k,1}$ head pull-through

ETA 3.9

Table 7.16.3 Characteristic values $F_{ax,\alpha,Rhead,k,1}$ of the load-bearing capacity [N] for washer head

	A	B	C	D	E	F	G	H	I
1				Outer thread diameter d_1 [mm]					
2				4.0	4.5	5.0	6.0	8.0	10.0
3				Head diameter d_h [mm]					
4				Flange head			Washer head		
5	Strength class		ρ_k [kg/m³]	9.6	10.6	11.6	13.6	20.0	25.0
6	C14		290	1538	1779	2014	2451	4474	6184
7	C16		310	1622	1876	2125	2585	4719	6522
8	C18		320	1664	1924	2179	2651	4840	6690
9	C20		330	1706	1972	2234	2717	4961	6857
10	C22	GL20h	340	1747	2020	2288	2783	5081	7023
11	C24		350	1788	2067	2341	2848	5200	7188
12		GL20c GL22c	355	1808	2091	2368	2881	5259	7270
13	C27		360	1829	2115	2395	2913	5319	7351
14		GL24c	365	1849	2138	2421	2946	5378	7433
15		GL22h	370	1869	2161	2448	2978	5436	7514
16	C30		380	1909	2208	2501	3042	5554	7676
17		GL26c GL24h	385	1930	2231	2527	3074	5612	7757
18	C35	GL28c GL30c	390	1950	2254	2553	3106	5670	7837
19	C40	GL32c	400	1989	2301	2605	3170	5786	7998
20		GL26h	405	2009	2323	2631	3201	5844	8078
21	C45		410	2029	2346	2657	3233	5902	8157
22		GL28h	425	2088	2415	2735	3327	6074	8395
23	C50	GL30h	430	2108	2438	2760	3358	6131	8474
24		GL32h	440	2147	2483	2812	3421	6245	8631
25		LVL	480	2302	2662	3014	3667	6695	9254
26	Pre-drilled hardwood								
27	D24		485	2321	2684	3040	3698	6751	9331
28	D30		530	2492	2881	3263	3970	7247	10017
29	D40		550	2567	2968	3361	4089	7465	10318
30	D50		620	2825	3267	3699	4500	8216	11356
31	D60		700	3113	3600	4077	4959	9054	12514
32		Beech LVL	730	3219	3722	4216	5129	9363	12941
33	Required in wood of same strength class $l_{ef} \geq$ [mm]			**32**	**33**	**33**	**40**	**54**	**63**
34	However, at least $l_{ef} \geq 4 \cdot d_1$			16	18	20	24	32	40

Tab. 7.16.3 b Increase factor

	A	B	C	D	E	F	H
1	Outer thread diameter d_1 [mm]	4.0	4.5	5.0	6.0	8.0	10.0
2	For $t_1 \geq 3 \cdot d_h$ [mm]	28.8	31.8	34.8	40.8	60.0	75.0
3	Increase by factor	**1.3**					

7. Withdrawal forces

Characteristic value $F_{ax,\alpha,Rhead,k,1}$ head pull-through

*see Table 8.7

Table 7.16.4 Characteristic values $F_{ax,\alpha,Rhead,k,1}$ of the load-bearing capacity [N] for countersunk head screws with partial thread and rosette washer*

	A	B	C	D	E	F	G
1				Screw nominal diameter d_1 [mm]			
2				6.0	8.0	10.0	12.0
3				Rosette washer diameter Da [mm]			
4	Strength class		ρ_k [kg/m³]	18.0	25.0	32.0	40.0
5	C14		290	3624	6184	7048	7048
6	C16		310	3822	6522	7434	7434
7	C18		320	3921	6690	7625	7625
8	C20		330	4018	6857	7815	7815
9	C22	GL20h	340	4115	7023	8004	8004
10	C24		350	4212	7188	8192	8192
11		GL 20c GL22c	355	4260	7270	8285	8285
12	C27		360	4308	7351	8379	8379
13		GL24c	365	4356	7433	8472	8472
14		GL22h	370	4403	7514	8564	8564
15	C30		380	4498	7676	8749	8749
16		GL26c GL24h	385	4546	7757	8841	8841
17	C35	GL28c GL30c	390	4593	7837	8933	8933
18	C40	GL32c	400	4687	7998	9116	9116
19		GL26h	405	4734	8078	9207	9207
20	C45		410	4780	8157	9297	9297
21		GL28h	425	4920	8395	9569	9569
22	C50	GL30h	430	4966	8474	9659	9659
23		GL32h	440	5058	8631	9838	9838
24		LVL	480	5423	9254	10547	10547
25	Pre-drilled hardwood						
26	D24		485	5468	9331	10635	10635
27	D30		530	5870	10017	11417	11417
28	D40		550	6047	10318	11760	11760
29	D50		620	6655	11356	12943	12943
30	D60		700	7334	12514	14263	14263
31		Beech LVL	730	7584	12941	14750	14750
32	Required in wood of same strength class $l_{ef} \geq$ [mm]			**59**	**75**	**71**	**62**
33	However, at least $l_{ef} \geq 4 \cdot d_1$			24	32	40	48

Rosette washers with a diameter Da > 32 mm are only calculated with a diameter of Da = 32 mm.

Tab. 7.3.4 a Increase factor

	A	B	C	D	E
1	Outer thread diameter d_1 [mm]	6.0	8.0	10.0	12.0
2	For $t_1 \geq 3 \cdot d_h$ [mm]	54.0	75.0	96.0	120.0
3	Increase by factor	**1.3**			

7. Pressing forces

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

ETA 3.9

Table 7.17.1 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N] for screws made of carbon steel

	A	B	C	D	E	F	G	H
1	SPAX®			Penetration angle α	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4				[°]	Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m^3]		4.0	5.0	6.1	7.35
6	C16		310	15	5779	9259	14093	20878
7				30	6002	9606	14607	21621
8				45	6198	9910	15057	22268
9				60	6371	10179	15454	22839
10				75	6527	10420	15808	23348
11				**90**	**6668**	**10637**	**16127**	**23806**
12	C18		320	15	5832	9341	14216	21056
13				30	6055	9688	14729	21797
14				45	6250	9991	15177	22441
15				60	6423	10260	15572	23010
16				75	6579	10499	15925	23516
17				**90**	**6719**	**10715**	**16243**	**23971**
18	C20		330	15	5884	9422	14334	21227
19				30	6106	9768	14847	21966
20				45	6301	10070	15293	22608
21				60	6474	10337	15687	23174
22				75	6628	10576	16038	23678
23				**90**	**6768**	**10791**	**16354**	**24130**
24	C22	GL20h	340	15	5933	9499	14449	21393
25				30	6156	9845	14960	22130
26				45	6350	10146	15405	22770
27				60	6522	10412	15797	23333
28				75	6676	10650	16147	23834
29				**90**	**6815**	**10864**	**16461**	**24284**
30	C24		350	15	5982	9574	14561	21554
31				30	6204	9919	15070	22288
32				45	6398	10220	15514	22925
33				60	6569	10485	15904	23486
34				75	6723	10722	16252	23985
35				**90**	**6861**	**10935**	**16565**	**24432**
36		GL20c GL22c	355	15	6005	9611	14615	21632
37				30	6227	9955	15124	22365
38				45	6421	10256	15567	23001
39				60	6592	10521	15956	23561
40				75	6745	10757	16303	24058
41				**90**	**6883**	**10969**	**16615**	**24504**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

ETA 3.9

Table 7.17.1 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N] for screws made of carbon steel

	A	B	C	D	E	F	G	H
1				Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m³]		4.0	5.0	6.1	7.35
6	C27		360	15	6029	9647	14669	21710
7				30	6250	9991	15177	22441
8				45	6444	10291	15619	23076
9				60	6615	10555	16008	23634
10				75	6768	10791	16354	24130
11				**90**	**6905**	**11003**	**16665**	**24575**
12		GL24c	365	15	6052	9683	14722	21786
13				30	6273	10027	15229	22516
14				45	6466	10326	15670	23150
15				60	6637	10590	16058	23707
16				75	6790	10825	16404	24201
17				**90**	**6927**	**11036**	**16714**	**24645**
18		GL22h	370	15	6074	9718	14774	21861
19				30	6295	10061	15280	22590
20				45	6488	10360	15720	23222
21				60	6659	10624	16108	23778
22				75	6811	10858	16452	24271
23				90	6948	11069	16762	24714
24	C30		380	15	6119	9787	14875	22007
25				30	6339	10129	15380	22734
26				45	6532	10427	15819	23364
27				60	6702	10690	16205	23917
28				75	6853	10923	16548	24408
29				**90**	**6990**	**11133**	**16855**	**24847**
30		GL26c GL24h	385	15	6140	9821	14925	22079
31				30	6361	10163	15430	22805
32				45	6553	10460	15867	23433
33				60	6723	10722	16252	23985
34				75	6874	10955	16594	24474
35				**90**	**7010**	**11164**	**16901**	**24913**
36	C35	GL28c GL30c	390	15	6162	9854	14974	22150
37				30	6382	10195	15478	22874
38				45	6574	10492	15915	23501
39				60	6743	10754	16299	24052
40				75	6894	10986	16640	24540
41				**90**	**7030**	**11195**	**16946**	**24977**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

ETA 3.9

Table 7.17.1 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl.k} / \gamma_{M1}$ [N] for screws made of carbon steel

	A	B	C	D	E	F	G	H
1	SPAX®			Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m³]		4.0	5.0	6.1	7.35
6	C40	GL32c	400	15	6204	9919	15070	22288
7				30	6423	10260	15572	23010
8				45	6615	10555	16008	23634
9				60	6784	10816	16390	24182
10				75	6934	11047	16730	24668
11				**90**	**7069**	**11255**	**17034**	**25103**
12		GL26h	405	15	6224	9951	15117	22356
13				30	6444	10291	15619	23076
14				45	6635	10586	16053	23700
15				60	6803	10846	16435	24246
16				75	6954	11077	16774	24731
17				**90**	**7089**	**11285**	**17077**	**25164**
18	C45		410	15	6244	9982	15164	22422
19				30	6464	10322	15664	23142
20				45	6655	10617	16098	23764
21				60	6823	10876	16479	24309
22				75	6973	11107	16817	24792
23				**90**	**7107**	**11314**	**17119**	**25225**
24		GL28h	425	15	6304	10074	15299	22617
25				30	6522	10412	15797	23333
26				45	6712	10706	16229	23951
27				60	6880	10964	16607	24492
28				75	7029	11193	16942	24972
29				**90**	**7162**	**11398**	**17243**	**25401**
30	C50	GL30h	430	15	6323	10104	15343	22681
31				30	6541	10442	15841	23395
32				45	6731	10735	16271	24012
33				60	6898	10992	16648	24552
34				75	7047	11220	16983	25030
35				**90**	**7180**	**11425**	**17283**	**25458**
36		GL32h	440	15	6361	10163	15430	22805
37				30	6579	10499	15925	23516
38				45	6768	10791	16354	24130
39				60	6934	11047	16730	24668
40				75	7082	11275	17063	25144
41				**90**	**7215**	**11479**	**17361**	**25569**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

ETA 3.9

Table 7.17.1 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl.k} / \gamma_{M1}$ [N] for screws made of carbon steel

	A	B	C	D	E	F	G	H
1	SPAX®			Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m³]		4.0	5.0	6.1	7.35
6		LVL	480	15	6503	10383	15754	23270
7				30	6719	10715	16243	23971
8				45	6905	11003	16665	24575
9				60	7069	11255	17034	25103
10				75	7215	11479	17361	25569
11				**90**	**7346**	**11679**	**17653**	**25986**
12	Pre-drilled hardwood							
13	D24		485	15	6520	10409	15792	23325
14				30	6735	10741	16280	24025
15				45	6922	11028	16702	24628
16				60	7085	11280	17070	25154
17				75	7231	11503	17396	25619
18				**90**	**7361**	**11702**	**17688**	**26035**
19	D30		530	15	6663	10630	16118	23792
20				30	6876	10958	16598	24480
21				45	7060	11240	17012	25072
22				60	7221	11488	17374	25588
23				75	7363	11706	17693	26043
24				**90**	**7491**	**11902**	**17978**	**26449**
25	D40		550	15	6723	10722	16252	23985
26				30	6934	11047	16730	24668
27				45	7117	11328	17140	25255
28				60	7277	11573	17499	25766
29				75	7418	11790	17815	26217
30				**90**	**7545**	**11984**	**18098**	**26619**
31	D50		620	15	6913	11014	16681	24599
32				30	7120	11333	17147	25264
33				45	7298	11606	17547	25835
34				60	7454	11845	17896	26331
35				75	7592	12056	18203	26768
36				**90**	**7715**	**12243**	**18476**	**27157**
37	D60		700	15	7101	11304	17105	25205
38				30	7304	11615	17559	25852
39				45	7477	11881	17948	26405
40				60	7629	12112	18285	26885
41				75	7762	12316	18582	27308
42				**90**	**7882**	**12498**	**18846**	**27683**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

ETA 3.9

Table 7.17.1 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N] for screws made of carbon steel

	A	B	C	D	E	F	G	H
1				Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m³]		4.0	5.0	6.1	7.35
6		Beech LVL	730	15	7165	11403	17250	25410
7				30	7366	11710	17699	26051
8				45	7538	11974	18083	26598
9				60	7688	12203	18417	27073
10				75	7820	12404	18710	27490
11				**90**	**7938**	**12584**	**18972**	**27861**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

Table 7.17.2 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N] for screws made of stainless steel

ETA 3.9

	A	B	C	D	E	F	G	H
1				Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m^3]		4.0	5.0	6.1	7.35
6	C16		310	15	3963	6283	9472	13911
7				30	4051	6416	9667	14187
8				45	4125	6530	9832	14421
9				60	4190	6628	9974	14623
10				75	4247	6714	10099	14800
11				**90**	**4297**	**6791**	**10210**	**14957**
12	C18		320	15	3984	6315	9519	13978
13				30	4071	6447	9712	14251
14				45	4145	6560	9875	14483
15				60	4209	6657	10016	14683
16				75	4265	6743	10140	14858
17				**90**	**4315**	**6818**	**10249**	**15013**
18	C20		330	15	4004	6346	9564	14042
19				30	4091	6477	9755	14312
20				45	4164	6589	9917	14542
21				60	4227	6685	10057	14740
22				75	4283	6770	10179	14913
23				**90**	**4332**	**6844**	**10287**	**15067**
24	C22	GL20h	340	15	4024	6376	9608	14103
25				30	4109	6506	9797	14371
26				45	4182	6616	9957	14599
27				60	4245	6712	10095	14795
28				75	4300	6795	10217	14967
29				**90**	**4349**	**6870**	**10324**	**15119**
30	C24		350	15	4043	6404	9649	14162
31				30	4128	6533	9837	14428
32				45	4200	6643	9995	14653
33				60	4262	6738	10133	14848
34				75	4316	6820	10253	15018
35				**90**	**4365**	**6894**	**10359**	**15169**
36		GL20c GL22c	355	15	4052	6418	9670	14191
37				30	4136	6547	9856	14456
38				45	4208	6656	10014	14680
39				60	4270	6750	10151	14873
40				75	4324	6832	10270	15043
41				**90**	**4372**	**6906**	**10376**	**15193**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

ETA 3.9

Table 7.17.2 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N] for screws made of stainless steel

	A	B	C	D	E	F	G	H
1	SPAX®			Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m³]		4.0	5.0	6.1	7.35
6	C27		360	15	4061	6432	9689	14219
7				30	4145	6560	9875	14483
8				45	4216	6669	10033	14706
9				60	4278	6762	10169	14899
10				75	4332	6844	10287	15067
11				**90**	**4380**	**6917**	**10393**	**15216**
12		GL24c	365	15	4070	6446	9709	14247
13				30	4154	6573	9894	14509
14				45	4225	6681	10051	14732
15				60	4286	6774	10186	14923
16				75	4340	6856	10304	15091
17				**90**	**4388**	**6928**	**10409**	**15240**
18		GL22h	370	15	4079	6459	9728	14274
19				30	4162	6586	9912	14535
20				45	4233	6693	10068	14757
21				60	4294	6786	10203	14948
22				75	4347	6867	10321	15115
23				**90**	**4395**	**6940**	**10425**	**15263**
24	C30		380	15	4095	6485	9766	14327
25				30	4178	6610	9948	14586
26				45	4248	6717	10103	14806
27				60	4309	6809	10236	14995
28				75	4362	6890	10353	15160
29				**90**	**4409**	**6961**	**10457**	**15307**
30		GL26c GL24h	385	15	4104	6497	9784	14353
31				30	4186	6622	9966	14611
32				45	4256	6729	10120	14829
33				60	4316	6820	10253	15018
34				75	4369	6901	10369	15183
35				**90**	**4416**	**6972**	**10472**	**15329**
36	C35	GL28c GL30c	390	15	4112	6509	9802	14379
37				30	4194	6634	9983	14635
38				45	4263	6740	10136	14853
39				60	4324	6831	10269	15040
40				75	4376	6911	10385	15205
41				**90**	**4423**	**6982**	**10487**	**15350**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

ETA 3.9

Table 7.17.2 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N] for screws made of stainless steel

	A	B	C	D	E	F	G	H
1	SPAX			Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m^3]		4.0	5.0	6.1	7.35
6	C40	GL32c	400	15	4128	6533	9837	14428
7				30	4209	6657	10016	14683
8				45	4278	6762	10169	14899
9				60	4338	6853	10300	15085
10				75	4390	6932	10415	15247
11				**90**	**4436**	**7002**	**10517**	**15392**
12		GL26h	405	15	4135	6545	9854	14452
13				30	4216	6669	10033	14706
14				45	4285	6773	10184	14921
15				60	4345	6863	10315	15106
16				75	4397	6942	10429	15268
17				**90**	**4443**	**7012**	**10531**	**15412**
18	C45		410	15	4143	6557	9870	14476
19				30	4224	6680	10049	14729
20				45	4292	6784	10200	14943
21				60	4351	6874	10330	15127
22				75	4403	6952	10444	15289
23				**90**	**4449**	**7022**	**10545**	**15432**
24		GL28h	425	15	4165	6590	9919	14545
25				30	4245	6712	10095	14795
26				45	4313	6815	10245	15006
27				60	4371	6904	10373	15189
28				75	4422	6981	10486	15348
29				**90**	**4468**	**7050**	**10586**	**15490**
30	C50	GL30h	430	15	4172	6601	9935	14567
31				30	4252	6722	10110	14816
32				45	4319	6825	10259	15027
33				60	4378	6913	10387	15209
34				75	4429	6991	10500	15368
35				**90**	**4474**	**7059**	**10599**	**15508**
36		GL32h	440	15	4186	6622	9966	14611
37				30	4265	6743	10140	14858
38				45	4332	6844	10287	15067
39				60	4390	6932	10415	15247
40				75	4441	7009	10526	15405
41				**90**	**4485**	**7077**	**10625**	**15545**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

Table 7.17.2 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl.k} / \gamma_{M1}$ [N] for screws made of stainless steel

ETA 3.9

	A	B	C	D	E	F	G	H
1	SPAX®			Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m³]		4.0	5.0	6.1	7.35
6		LVL	480	15	4238	6701	10080	14773
7				30	4315	6818	10249	15013
8				45	4380	6917	10393	15216
9				60	4436	7002	10517	15392
10				75	4485	7077	10625	15545
11				**90**	**4529**	**7143**	**10721**	**15681**
12	Pre-drilled hardwood							
13	D24		485	15	4244	6711	10093	14792
14				30	4321	6827	10262	15031
15				45	4386	6926	10405	15234
16				60	4442	7011	10529	15408
17				75	4491	7085	10636	15561
18				**90**	**4534**	**7151**	**10732**	**15697**
19	D30		530	15	4295	6788	10206	14952
20				30	4370	6902	10371	15185
21				45	4433	6997	10509	15381
22				60	4487	7080	10629	15551
23				75	4535	7152	10734	15699
24				**90**	**4577**	**7216**	**10826**	**15831**
25	D40		550	15	4316	6820	10253	15018
26				30	4390	6932	10415	15247
27				45	4452	7027	10552	15442
28				60	4506	7108	10670	15609
29				75	4553	7180	10774	15756
30				**90**	**4595**	**7243**	**10865**	**15885**
31	D50		620	15	4383	6921	10398	15224
32				30	4453	7028	10554	15445
33				45	4513	7119	10686	15632
34				60	4565	7198	10800	15792
35				75	4610	7266	10899	15933
36				**90**	**4650**	**7327**	**10987**	**16058**
37	D60		700	15	4447	7019	10540	15425
38				30	4515	7122	10690	15637
39				45	4573	7209	10816	15816
40				60	4622	7285	10926	15971
41				75	4666	7351	11021	16106
42				**90**	**4704**	**7409**	**11106**	**16226**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

7. Pressing force

Design value $\kappa_c \cdot N_{pl,k} / \gamma_{M1}$ [N]

Table 7.17.2 Design value of the load-bearing capacity against buckling $\kappa_c \cdot N_{pl.k} / \gamma_{M1}$ [N] for screws made of stainless steel

ETA 3.9

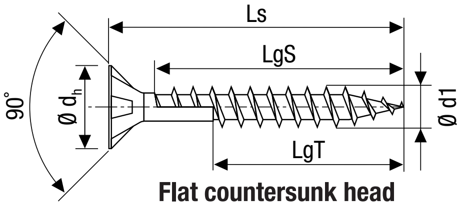
	A		C	D	E	F	G	H
1	SPAX			Penetration angle α [°]	$\kappa_c \cdot N_{pl,k} / \gamma_{M1}$			
2					Outer thread diameter d_1 [mm]			
3					6.0	8.0	10.0	12.0
4					Core diameter d_2 [mm]			
5	Strength class		ρ_k [kg/m^3]		4.0	5.0	6.1	7.35
4		Beech LVL	730	15	4469	7052	10588	15493
5				30	4536	7154	10736	15702
6				45	4593	7240	10860	15879
7				60	4641	7314	10968	16031
8				75	4684	7379	11062	16164
9				**90**	**4722**	**7436**	**11146**	**16283**

Note: Above values are design values with $\gamma_{m,1} = 1.1$ according to EN 1993 + NA!

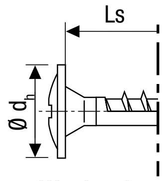
8. Quick overview of product range

The following tables represent a part of the product range.
Further dimensions or designs can be found under www.spax.com → Screw finder

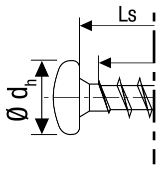
Dimensions and description



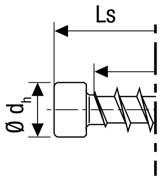
Flat countersunk head



Washer head or flange head



Pan head



Cylindrical head

Table 8.1 Full thread

	AB	B	C	D	F		G	H	I
1	Full thread							Full thread	
2	Carbon steel							Stainless steel 1.4578	
3		ETA-12/0114							
4	d_1	6.0	8.0	6.0	8.0	10.0	12.0	10.0	12.0
5	Head shape	Cylindrical head		Flat countersunk head				Flat countersunk head	
6	d_h	8.4	10.0		15.1	18.6	18.6	18.6	18.6
7	Point	4CUT	CUT	4CUT	CUT	CUT	CUT	CUT	CUT
8	Length increment Ls	Ls						Ls	
9	every 20 mm	80 - 200	160 - 300	50 - 200	120 - 300	120, 160, 200 - 300	200, 240, 280, 300	160, 200 - 300	-
10	every 50 mm	-	350 - 600		250 - 600	350 - 600	350 - 600	350 - 400	400 - 550
12						700, 800			

Table 8.2 Pan head

	A	B	C	D	E	F	G
1	Carbon steel					Stainless steel 1.4567	
2	Pan head					Pan head	
3		ETA-12/0114					
4	d_1	4.0	4.5	5.0	6.0	4.0	5.0
5	d_h	8.0	9.0	9.9	11.9	8.0	9.9
6	Point	4CUT	4CUT	4CUT	4CUT	4CUT	4CUT
7	Ls	lg	lg	lg	lg	lg	lg
8	20	18				18	
9	25	23	22	22		23	22
10	30	27	27	27	27	27	27
11	35	32	32	32	32	32	
12	40	37	37	37	37	37	37
13	45	42	42	41		42	
14	50	47	47	46	46	47	46
15	60	50	57	56	56		
16	70			61	61		
17	80			61	61		
18	90			61	61		
19	100				61		

lg = Thread length
For SPAX with outer thread diameter d_1 4.0 mm see SPAX ETA-12/0114.

8. Quick overview of product range

Table 8.3 Flat countersunk head carbon steel

	A	B	C	D	E	F	G	H	I	J	K
1	Carbon steel										
2	Flat countersunk head										
3		ETA-12/0114									
4	d_1	4.0		4.5		5.0		6.0		8.0	10.0
5	d_h	8.0		8.8		9.7		11.6		15.1	18.6
6	Point	4CUT		4CUT		4CUT		4CUT		4CUT	4CUT
7	Ls	IgV	IgT	IgV	IgT	IgV	IgT	IgV	IgT	IgT	IgT
8	20	16									
9	25	21		20		20					
10	30	25	18	25		25		24			
11	35	30	23	30	25	30	25	29			
12	40	35	23	34	25	35	27	34	24		
13	45	40	30	39	30	39	30	38			
14	50	45	32	44	32	44	32	43	32		
15	55	50	35	49	37	49	37				
16	60	50	35	54	37	54	37	53	37		
17	70	50	37	59	42	61	41	61	41		
18	80	50	37	59	47	61	46	61	46	47	50
19	90						61		61		
20	100						61		61	57	60
21	110						69		68		
22	120						69		68	70	80
23	130								68		
24	140								68	80	80
25	150								68		
26	160								65	80	80
27	180								65	80	80
28	200								65	80	80
29	220								65	80	80
30	240								65	80	80
31	260								65	80	80
32	280								65	80	80
33	300								65	80	80
34	320									80	80
35	340									80	80
36	350										
37	360									80	80
38	380									80	80
39	400									80	80
40	450									80	80
41	500										
42	550										
43	600										

IgV = Full thread
IgT = Partial thread
For SPAX with outer thread diameter d_1 4.0 mm see SPAX ETA-12/0114.

8. Quick overview of product range

Table 8.4 Flat countersunk head stainless steel

	A	B	C	D	E	F	G	H	I	J
1	Stainless steel 1.4567									
2	Flat countersunk head									
3		ETA-12/0114								
4	d_1	4.0		4.5		5.0		6.0		8.0
5	d_h	8.0		8.8		9.7		11.6		15.1
6	Point	4CUT		4CUT		4CUT		4CUT		4CUT
7	Ls	IgV	IgT	IgV	IgT	IgV	IgT	IgV	IgT	IgT
8	20	16								
9	25	21		20						
10	30	25	18	25		25				
11	35	30	23	30	25	30				
12	40	35	23	34	25	35	27	34		
13	45	40	30	39	30	39	30			
14	50	45	32	44	32	44	32	43		
15	60	50		54	37	54	37	53	37	
16	70			59	42	61	41	61	41	
17	80					61	46	61	46	47
18	90						61		61	
19	100						61		61	57
20	120						69		68	70
21	140								68	80
22	160								65	80
23	Up to 300 mm in 20 mm gradation:									80

IgV = Full thread, IgT = Partial thread

Table 8.5 Flat countersunk head stainless steel with CUT point

	A	B	C	D	E
1	Stainless steel 1.4567				
2	Flat countersunk head				
3		ETA-12/0114			
4	d_1	4.5		5.0	
5	d_h	8.8		9.7	
6	Point	CUT		CUT	
7	Ls	IgT		IgT	
8	35	25			
9	40	25			
10	45	30			
11	50	32			
12	60	37		37	
13	70	42		41	
14	80	47		46	
15	90			61	
16	100			61	

IgT = Partial thread

8. Quick overview of product range

Table 8.6 Washer head or flange head

	A	B	C	D	E	F	G	H	I
1	Carbon steel							Stainless steel 1.4567	
2		Flange head			Washer head			Washer head	
3		ETA-12/0114							
4	d_1	4.0	4.5	5.0	6.0	8.0	10.0	6.0	8.0
5	d_h	9.6	10.6	11.6	13.6	20.0	25.0	13.6	20.0
6	Point	4CUT	4CUT	4CUT	4CUT	4CUT	4CUT	4CUT	4CUT
7	Ls	lg	lg	lg	lg	lg	lg	lg	lg
8	20	18							
9	25	23	22	22					
10	30	27	27	27					
11	35	32	32	32					
12	40	37	37	37	37				
13	45	42	42	41					
14	50		47	46		46			46
15	60			56	56			56	56
16	77			46					
17	80				61	70	70	61	70
18	87			46					
19	100				61	80	80	61	80
20	107			46					
21	120				68	80	80	68	80
22	140				68	80	80	68	80
23	160				65	80	80		80
24	180				65	80	80		80
25	200				65	80	80		80
26	220				65	80	80		80
27	240				65	80	80		80
28	250				65				
29	260					80	80		80
30	280				65	80	80		80
31	300				65	80	80		80
32	320					80	80		
33	340					80	80		
34	360					80	80		
35	380					80	80		
36	400					80	80		
37	450					80	80		
38	500					80			
39	550					80			

lg = Thread length
For SPAX with outer thread diameter $d_1 < 4.0$ mm see ETA-12/0114.

8. Quick overview of product range

Washers commercially available

Figure 8.1 Washers for screws with flat countersunk head (= rosette washers)

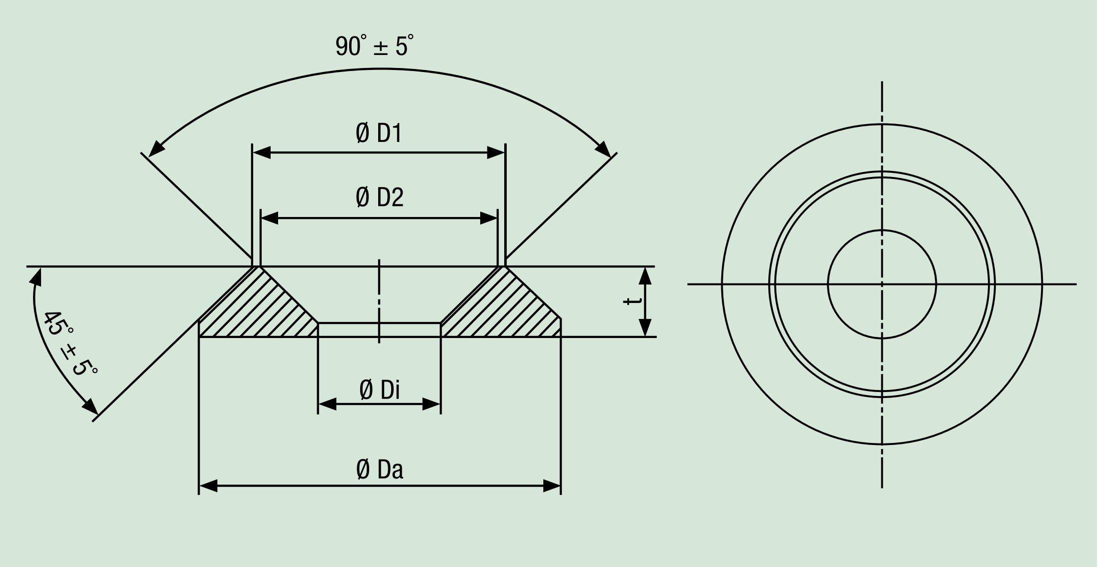


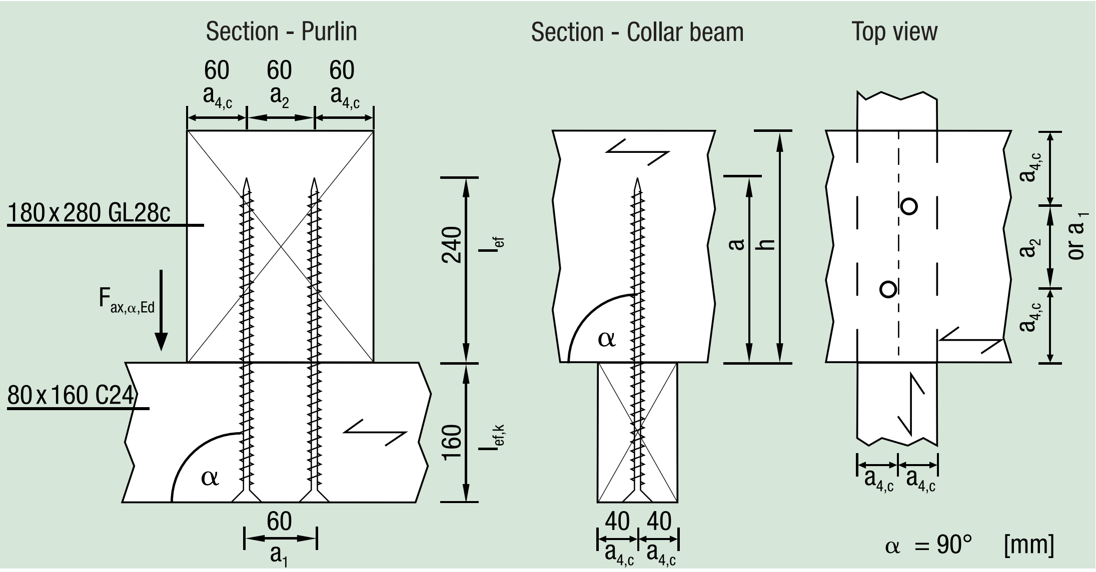
Table 8.7 Washers for screws with flat countersunk head (= rosette washers)

	A	B	C	D	E	F
1	Thread size	6.0	8.0	10.0	12.0	Tolerance
2	Ø Da	18.0	25.0	32.0	40.0	± 0.3
3	Ø Di	6.5	8.5	11.0	13.0	
4	Ø D1	13.5	17.5	22.5	27.0	
5	Ø D2	12.5	16.5	21.5	26.0	
6	t	3.5	5.0	5.6	7.0	

9. Examples wood to wood 1 withdrawal force

Collar beam at purlin with full-thread screw

Further information is available in the SPAX wood construction report No.2



$F_{ax,\alpha,Ed}$ = 14.2 kN

SC = 1, LDC = Medium -> k_{mod} = 0.8 (Tab. 4.3; F2+F5)

Selected: SPAX flat countersunk head 8.0 x 400 full thread with CUT point, according to SPAX ETA-12/0114 without pre-drilling
Load for withdrawal forces

Minimum spacings for SPAX for withdrawal only (Tab. 6.3 b; F5)

Since the SPAX is only loaded axially, the following minimum spacings can be assumed:

$a_1 = 5 \cdot d_1 = 5 \cdot 8.0$ mm = 40 mm Selected a_1 = 60 mm -> Fulfilled
$a_2 = 5 \cdot d_1 = 5 \cdot 8.0$ mm = 40 mm Selected a_2 = 60 mm -> Fulfilled
$a_{3,c} = 5 \cdot d_1 = 5 \cdot 8.0$ mm = 40 mm Available $a_{3,c}$ >> 40 mm -> Fulfilled
$a_{4,c} = 3 \cdot d_1 = 3 \cdot 8.0$ mm = 24 mm Selected $a_{4,c}$ = 40 mm -> Fulfilled

Minimum wood thickness t_{min} = $12 \cdot d_1 = 12 \cdot 8.0$ mm = 96 mm (Tab. 6.3 b; F) ETA 3.11
Collar beam t_{vorh} = 160 mm > 96 mm -> Fulfilled
Purlin t_{vorh} = 280 mm > 96 mm -> Fulfilled

Further specification: Point with 4CUT or CUT point -> Fulfilled (Tab. 6.3 b; F4) ETA 3.11

9. Examples wood to wood 1 withdrawal force

Collar beam at purlin with full-thread screw

Load-bearing capacity withdrawal force per screw $F_{ax,\alpha,Rd}$

1. Withdrawal force of the thread

$l_{ef} = 240\ \text{mm}$

$R_{ax,k,2} = 104.7\ \text{N/mm} \cdot 240\ \text{mm} =$ 25.128 N (Tab. 7.14; I14)

$\gamma_M = 1.3$

$R_{ax,d,2} = \frac{0.8 \cdot 25.128\ \text{N}}{1.3} =$ 15.463 N

2. Tensile capacity (steel)

$f_{tens,k} =$ 17,000 N (Tab. 7.15; G3)

$\gamma_M = 1.3$

$f_{tens,d} = \frac{17{,}000\ \text{N}}{1.3} =$ 13,077 N (Tab. 7.15; G4)

3. Head pull-through

$$\text{Max.} \begin{cases} \text{3.1 Head pull-through} \\ \text{3.2 Head-end thread load-bearing capacity} \end{cases}$$

3.1 Head pull-through

$R_{head,k,1} = 2{,}713 \cdot 1.3$ 3,527 N (Tab. 7.16.1;H11 · Tab. 7.16.1 b; F3)

$\gamma_M = 1.3$

$R_{head,d,1} = \frac{0.8 \cdot 25.128\ \text{N}}{1.3} =$ 2,170 N

3.2 Head-end thread load-bearing capacity

$l_{ef,k} = 160\ \text{mm}$

$R_{ax,k,1} = 96.0\ \text{N/mm} \cdot 160\ \text{mm} =$ 15,360 N (Tab. 7.14; I7)

$\gamma_M = 1.3$

$R_{ax,d,1} = \frac{0{,}8 \cdot 25.128\ \text{N}}{1.3} =$ $\underline{\underline{9.452\ \text{N}}}$

Design value of the load-bearing capacity withdrawal force - decisive failure case

$$F_{ax,\alpha,Rd} = \min \begin{cases} R_{ax,d,2} & = 15{,}463\ \text{N} \\ f_{tens,d} & = 13{,}077\ \text{N} \\ \text{Max.} \begin{cases} R_{head,d,1} & = 2{,}170\ \text{N} \\ R_{ax,d,1} & = \underline{\underline{9{,}452\ \text{N}}} \quad \text{decisive} \end{cases} \end{cases}$$

Verification of load-bearing capacity withdrawal force

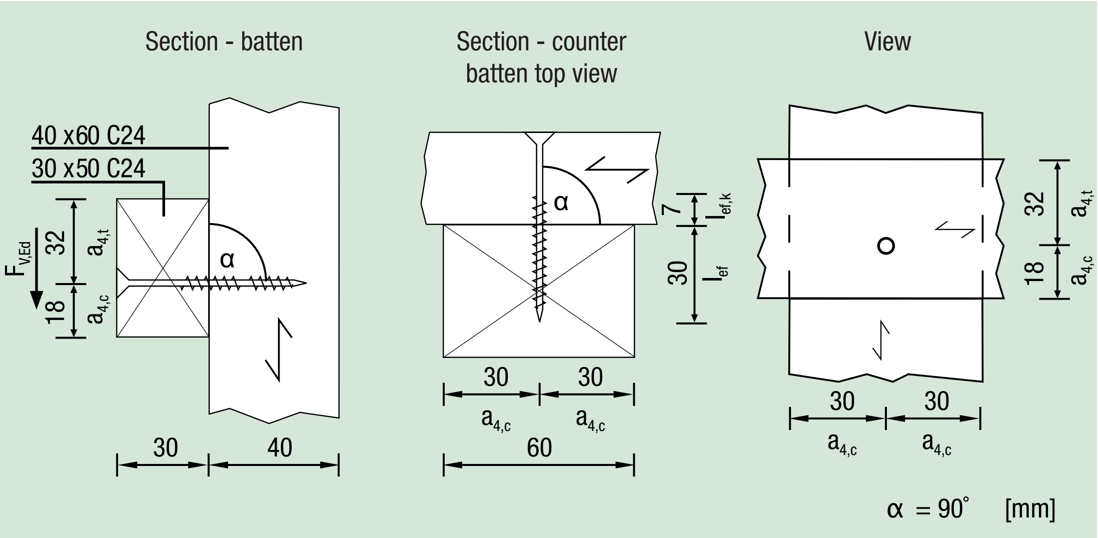
$$\frac{F_{ax,a,Ed}}{n_{ef} \cdot F_{ax,a,Rd}} = \frac{14.200\ \text{N}}{2^{0.9} \cdot 9.452\ \text{N}} = 0.081<1.0 \text{ Verification fulfilled}$$

Component verification

Since a/h > 0.7 (L_{ef} = 240 mm > $t_2 \cdot 0.7$ = 196 mm), verification is not required for the transverse stresses caused by this in wood 2. NA/A1; 8.1.4

9. Examples wood to wood 2 shear forces

Batten on counter batten



$F_{v,Ed} = 0.7$ kN

SC = 2, LDC = Short -> $k_{mod} = 0.9$ (Tab. 4.3; G3)

Selected: SPAX flat countersunk head 4.5 x 60 partial thread, 4CUT point, stainless steel A2, 1.4567
according to SPAX ETA-12/0114 without pre-drilling
Head diameter d_h= 8.8 mm (Tab. 8.4; E5)
Partial thread length IgT = 37 mm (Tab. 8.4; E15)
Load for shear forces

Minimum wood dimensions to prevent wood splitting (Tab. 6.3 b; C)

For SPAX with d_1 = 4.5 mm minimum cross-section area
$A_{min} = 40 \cdot d_1^2 = 40 \cdot 4.5^2$ mm² = 810 mm² (Tab. 6.3 b; C2) ETA 3.11

Batten: Cross-section area A = 50 mm · 30 mm = 1,500 mm² > 810 mm² -> Fulfilled
Counter batten: Cross-section area A = 40 mm · 60 mm = 2,400 mm² > 810 mm² -> Fulfilled

Minimum wood thickness $t_{min} = 6 \cdot d_1 = 6 \cdot 4.5$ mm = 27 mm (Tab. 6.3 b; C5) ETA 3.11
Batten t_{vorh} = 30 mm > 27 mm -> Fulfilled
Counter batten t_{vorh} = 40 mm > 27 mm -> Fulfilled

Further specification: 4CUT point -> Fulfilled (Tab. 6.3 b; C4)

Minimum spacings for SPAX loaded in shear or combined (Tab. 6.3 b; C)

$a_{4,t} = 3 + 2 \cdot \sin(\alpha') \cdot d_1 = 5 \cdot 4.5$ mm = 22.5 mm selected $a_{4,t}$ = 32 mm -> Fulfilled
$a_{4,c} = 3 \cdot d_1 = 3 \cdot 4.5$ mm = 13.5 mm selected $a_{4,c}$ = 18 mm -> Fulfilled

9. Examples wood to wood 2 shear forces

Batten on counter batten

Load-bearing capacity shear forces per screw $F_{v,Rd}$

1. Minimum wood thickness or minimum penetration depth t_{req} for formation of a reinforcement flow

t_1 = 30 mm > $t_{1,req}$ = 29.0 mm · 0.816 = 23.7 mm -> Fulfilled (Tab. 7.1.1; E8 · Tab. 7.1 a; C3)
$t_{2,req}$ = 60 mm - 30 mm = 30 mm > $t_{2,req}$
$t_{2,req}$ = 29.0 mm · 0.816 = 23.7 mm -> Fulfilled (Tab. 7.1.1; E8 · Tab. 7.1 a; C3)
-> Reduction of the characteristic value of the load-bearing capacity $F_{v,Rk}$ not required!

2. Design value of the load-bearing capacity shear forces $F_{v,Rd}$

$F_{v,Rk}$ = 989 N · 0.816 = 807
γ_M = 1.3 (Tab. 7.2.1; E8 · Tab. 7.3 a; C3)

Rope effect ΔR_k

$$\Delta R_k = \min \begin{cases} 807\ \text{N} \\ 352 \cdot 1.3\ \text{N} = \quad 458\ \text{N (decisive)} \end{cases}$$ (Tab. 7.3.1; E9 · Tab. 7.16.1 b; C3)

$F_{v,Rk}$ = 807 N + 458 N = 1,265 N
γ_M = 1.3

$$F_{v,Rd} = \frac{0.9 \cdot 1{,}265\ \text{N}}{1.3} = \underline{\underline{876\ \text{N}}}$$

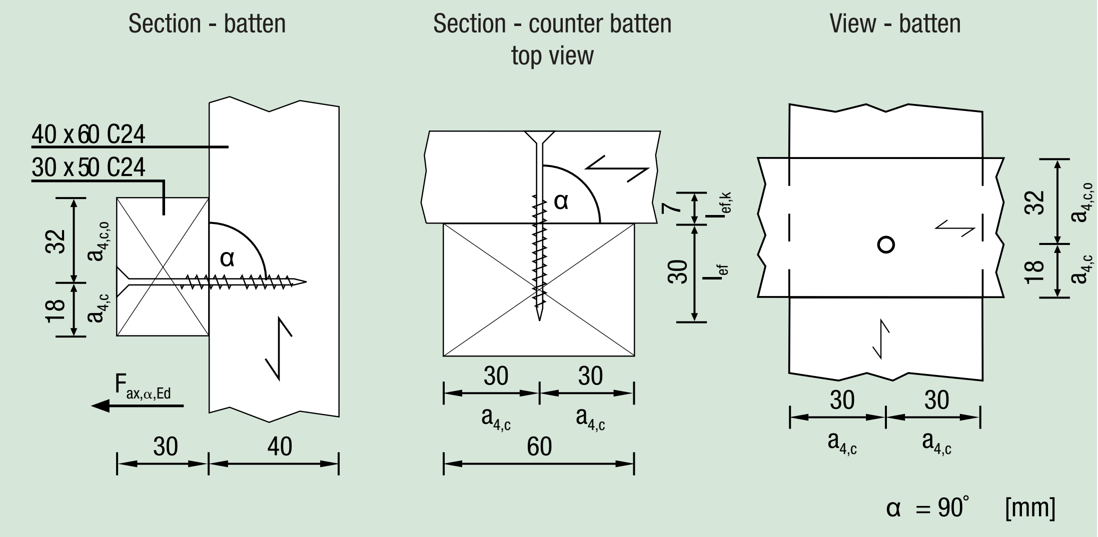
Verification of load-bearing capacity shear forces

$$\frac{F_{v,Ed}}{n_{ef} \cdot F_{v,Rd}} \geq 1 \quad = \frac{700\ \text{N}}{1 \cdot 876\ \text{N}} = 0.8 < 1.0$$ Verification fulfilled

Minimum number of fasteners per component, see section 6.1 General.

9. Examples wood to wood 3 withdrawal force

Batten on counter batten



$F_{ax,\alpha,Ed} = 0.4$ kN

SC = 2, LDC = Short -> $k_{mod} = 0.9$ (Tab. 4.3; G3)

Selected: SPAX flat countersunk head 4.5 x 60 partial thread, 4CUT point, stainless steel A2, 1.4567 according to SPAX ETA-12/0114 without pre-drilling
Head diameter d_h= 8.8 mm (Tab. 8.4; E5)
Partial thread length lgT = 37 mm (Tab. 8.4; E15)
Load for withdrawal force

Minimum wood dimension to prevent wood splitting (Tab. 6.3 b; C)

For SPAX with $d_1 = 4.5$ mm minimum cross-section area
$A_{min} = 40 \cdot d_1^2 = 40 \cdot 4.5^2$ mm² = 810 mm² (Tab. 6.3 b; C2) ETA 3.11

Batten: Cross-section area A = 50 mm · 30 mm = 1,500 mm² > 810 mm² -> Fulfilled
Counter batten: Cross-section area A = 40 mm · 60 mm = 2,400 mm² > 810 mm² -> Fulfilled

Minimum wood thickness $t_{min} = 6 \cdot d_1 = 6 \cdot 4.5$ mm = 27 mm (Tab. 6.3 b; C5) ETA 3.11
Batten $t_{vorh} = 30$ mm > 27 mm -> Fulfilled
Counter batten $t_{vorh} = 40$ mm > 27 mm -> Fulfilled

Further specification: 4CUT point -> Fulfilled (Tab. 6.3 b; C4)

Minimum spacings for SPAX loaded in shear or combined (Tab. 6.3 b; C)

$a_{4,c} = 3 \cdot d_1 = 3 \cdot 4.5$ mm = 13.5 mm Selected $a_{4,c}$ = 32 mm -> Fulfilled
$a_{4,c} = 3 \cdot d_1 = 3 \cdot 4.5$ mm = 13.5 mm Selected $a_{4,c}$ = 18 mm; 30 mm -> Fulfilled

9. Examples wood to wood 3 withdrawal force

Batten on counter batten

Load-bearing capacity withdrawal force per screw $F_{ax,\alpha,Rd}$

1. Withdrawal force of the thread

$$l_{ef} = \min \begin{cases} t_2 = 30 \text{ mm (decisive)} \\ \text{lgT} = 37 \text{ mm} \end{cases}$$

$R_{ax,k,2} = 63.0 \text{ N/mm} \cdot 30 \text{ mm} =$ 1,890 N (Tab. 7.14; F7)

$\gamma_M = 1.3$

$R_{ax,k,2} = \frac{0.9 \cdot 1.890 \text{ N}}{1.3} =$ 1,130 N

2. Tensile capacity (steel)

$f_{tens,k}$ 4,200 N (Tab. 7.15; D5)

$\gamma_M = 1.3$

$f_{tens,d} = \frac{4.200 \text{ N}}{1.3} =$ 3,231 N (Tab. 7.15; D6)

3. Head pull-through

$$\text{Max.} \begin{cases} \text{3.1 Head pull-through} \\ \text{3.2 Head-end thread load-bearing capacity} \end{cases}$$

3.1 Head pull-through

$R_{head,k,1} = 1.409 \text{ N} \cdot 1.3 =$ 1,832 N (Tab. 7.16.1;E11 · Tab. 7.16.1)

$\gamma_M = 1.3$

$R_{head,d,1} = \frac{0.9 \cdot 1.832 \text{ N}}{1.3} =$ $\underline{\underline{1,268 \text{ N}}}$ (decisive)

3.2 Head-end thread load-bearing capacity

$l_{ef,k} = 37 \text{ mm} - 30 \text{ mm} = 7 \text{ mm}$

$R_{ax,k,1} = 63.0 \text{ N/mm} \cdot 7 \text{ mm} =$ 441 N (Tab. 7.14; F7)

$\gamma_M = 1.3$

$R_{ax,d,1} = \frac{0.9 \cdot 441 \text{ N}}{1.3} =$ 305 N

Design value of the load-bearing capacity withdrawal force $F_{ax,\alpha,Rd}$ - decisive failure case

$$F_{ax,\alpha,Rd} = \min \begin{cases} R_{ax,d,2} & = 1,890 \text{ N} \\ f_{tens,d} & = 3,231 \text{ N} \\ \text{Max.} \begin{cases} R_{head,d,1} & = \underline{\underline{1,268 \text{ N}}} \quad \text{decisive} \\ R_{ax,d,1} & = 305 \text{ N} \end{cases} \end{cases}$$

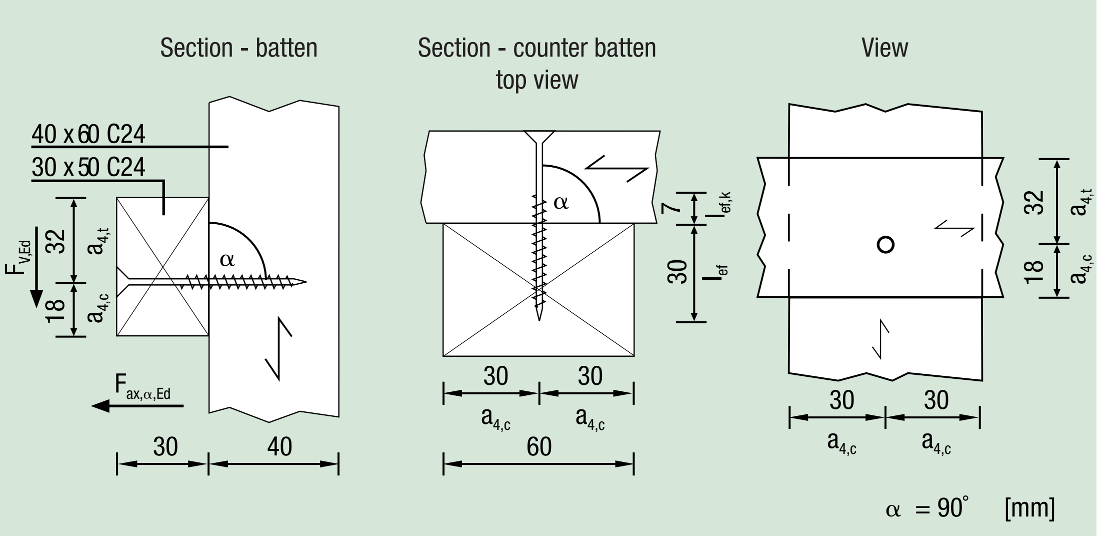
Verification of load-bearing capacity withdrawal force

$$\frac{F_{ax,\alpha,Ed}}{n_{ef} \cdot F_{ax,a,Rd}} = \frac{400 \text{ N}}{1 \cdot 1.128 \text{ N}} = 0.32 < 1.0 \quad \text{Verification fulfilled}$$

Minimum number of fasteners per component, see section 6.1 General.

9. Examples wood to wood 4 shear forces and withdrawal forces combined

Batten on counter batten



$F_{v,Ed} = 0.7$ kN

$F_{ax,\alpha,Ed} = 0.4$ kN

SC = 2, LDC = Short -> $k_{mod} = 0.9$

(Tab. 4.3; G3)

Selected: SPAX flat countersunk head 4.5 x 60 partial thread, 4CUT point, stainless steel A2, 1.4567 according to SPAX ETA-12/0114 without pre-drilling

Head diameter d_h = 8.8 mm (Tab. 8.4; E5)

Partial thread length lgT = 37 mm (Tab. 8.4; E15)

Load for shear forces and withdrawal forces (combined)

The design values of the effects from the examples wood to wood 2 and wood to wood 3 are combined.

The specification and design values of the load-bearing capacity were already checked in the respective examples and selected in such a way that minimum spacings from the respective examples were suitable for each other.

Verification of the load-bearing capacity shear forces and withdrawal forces

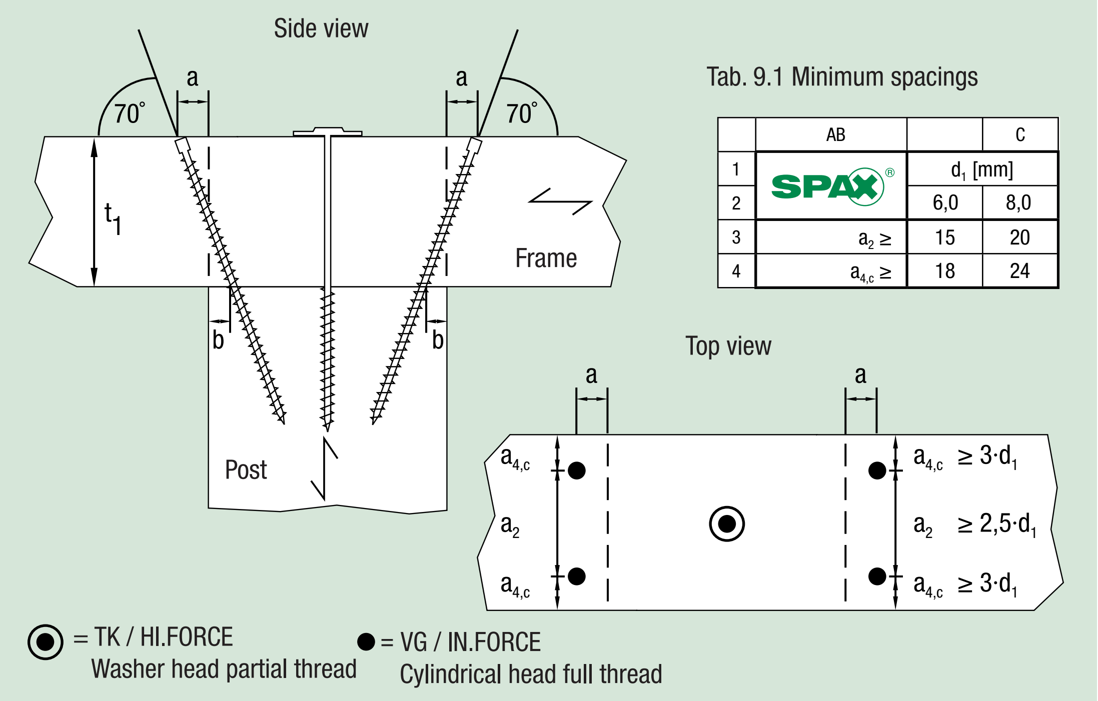
$$\left(\frac{F_{v,Ed}}{n_{ef} \cdot F_{v,Rd}}\right)^2 + \left(\frac{F_{ax,\alpha,Ed}}{n_{ef} \cdot F_{ax,\alpha,Rd}}\right)^2 = \left(\frac{700\ \text{N}}{1 \cdot 876\ \text{N}}\right)^2 + \left(\frac{400\ \text{N}}{1 \cdot 1.268\ \text{N}}\right)^2$$

$= 0.8^2 + 0.32^2 = 0.64 + 0.1 = 0.74 < 1.0$ Verification fulfilled

Minimum number of fasteners per component, see section 6.1 General.

9. Execution example T-joint

Frame at post



Tab. 9.1 Minimum spacings

	AB		C
1	SPAX	d_1 [mm]	
2		6,0	8,0
3	$a_2 \geq$	15	20
4	$a_{4,c} \geq$	18	24

Softwood:	Wood components may be pre-drilled For $d_1 \geq 8$ mm without pre-drilling only for wood types spruce, pine and fir
Hardwood:	Wood components **must** be pre-drilled

For pre-drilling of the wood component for SPAX the preferred dimension of the drilling diameter can be selected according to the following table.

Table 9.2 Preferred dimensions for the drilling diameter for pre-drilled woods depending on the SPAX nominal diameter

	A	B	C
1	SPAX	Nominal-Ø d_1 [mm]	
2		6.0	8.0
3	Softwood	4.0	5.0
4	Hardwood	4.0	6.0

Further information is available in the SPAX wood construction report No. 6.

9. Execution example T-joint

Frame at post

Table 9.3 Screw selection washer head / HI.FORCE and full thread / IN.FORCE

The screw lengths of the VG / IN.FORCE screws are calculated in such a way that their points do not touch! The specification of the characteristic value of the load-bearing capacity for withdrawal force $F_{ax,\alpha,Rk}$ refers to a VG / IN.FORCE screw. For the dimensioning of a connection the effective number of screws n_{ef} must be determined with which the load-bearing capacity for the screw group can be determined.
The value $F_{ax,\alpha,Rk}$ refers to the respective VG / IN.FORCE screw in combination with softwood C24.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	SPAX			Frame height [mm]															
2				95		100		120		140		160		180		200		240	
3				d_1	Ls	d_1	Ls	d_1	Ls	d_1	Ls	d_1	Ls	d_1	Ls	d_1	Ls	d_1	Ls
4	Post width [mm]	95	TK/ HI.FORCE	6.0	160	6.0	180	8.0	200	8.0	220	8.0	240						
5			VG / IN.FORCE	6.0	200	6.0	200	8.0	220	8.0	240	8.0	260						
6			$F_{ax,\alpha,Rk}$ [N]	6052		5727		7531		7426		7321							
7			Dimension a [mm]	25		26		34		41		48							
8			Dimension b [mm]	10		10		10		10		10							
9		100	TK/ HI.FORCE	6.0	160	6.0	180	8.0	200	8.0	220	8.0	240	8.0	260	8.0	280	8.0	320
10			VG / IN.FORCE	6.0	200	6.0	200	8.0	220	8.0	240	8.0	260	8.0	280	8.0	300	8.0	350
11			$F_{ax,\alpha,Rk}$ [N]	6052		5727		7531		7426		7321		7217		7112		7718	
12			Dimension a [mm]	25		26		29		36		43		51		58		72	
13			Dimension b [mm]	10		10		15		15		15		15		15		15	
14		120	TK/ HI.FORCE			6.0	180	8.0	200	8.0	220	8.0	240	8.0	260	8.0	280	8.0	320
15			VG / IN.FORCE			6.0	200	8.0	240	8.0	260	8.0	280	8.0	300	8.0	350	8.0	350
16			$F_{ax,\alpha,Rk}$ [N]			5727		9163		9058		8953		8848		11191		7718	
17			Dimension a [mm]			21		24		31		38		46		63		67	
18			Dimension b [mm]			15		20		20		20		20		10		20	
19		140	TK/ HI.FORCE					8.0	200	8.0	220	8.0	240	8.0	260	8.0	280	8.0	320
20			VG / IN.FORCE					8.0	260	8.0	280	8.0	300	8.0	300	8.0	350	8.0	400
21			$F_{ax,\alpha,Rk}$ [N]					10794		10690		10585		8848		11191		11798	
22			Dimension a [mm]					24		31		38		46		53		67	
23			Dimension b [mm]					20		20		20		20		20		20	
24		160	TK/ HI.FORCE							8.0	220	8.0	240	8.0	260	8.0	280	8.0	320
25			VG / IN.FORCE							8.0	300	8.0	300	8.0	350	8.0	350	8.0	400
26			$F_{ax,\alpha,Rk}$ [N]							12321		10585		12928		11191		11798	
27			Dimension a [mm]							31		38		46		53		67	
28			Dimension b [mm]							20		20		20		20		20	

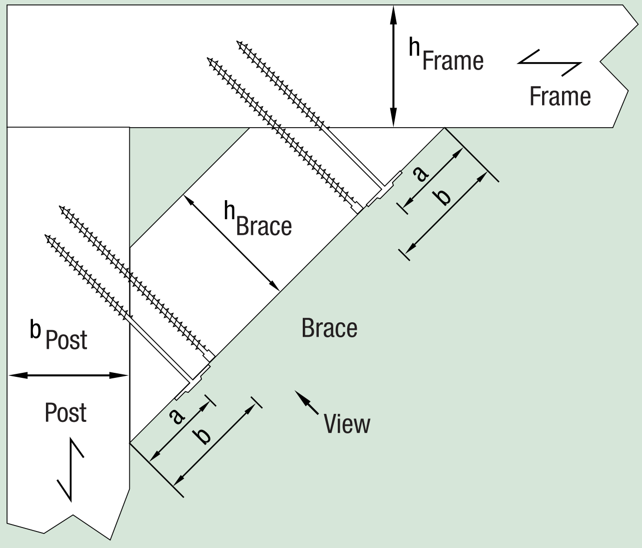
t_1 is always $\geq 12 \cdot d_1$. Thus the reduced minimum spacings valid for SPAX can be used for screws subject solely to tensile stress, also without pre-drilling of the wood components.

Characteristic withdrawal parameter for SPAX with d_1 = 6.0 mm and 8.0 mm under an angle α to the wood grain in combination with softwood C24:
$f_{ax,70°,k} = 11.726$ N/mm²
$f_{ax,20°,k} = 10.199$ N/mm²

9. Execution example brace

Brace at frame and at post

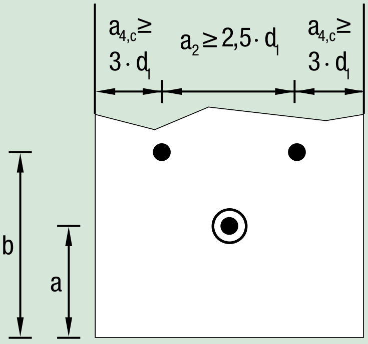
Side view



Tab. 9.4 Minimum spacings

	AB		C
1		d_1 [mm]	
2		6,0	8,0
3	a2 ≥	15	20
4	a4,c ≥	18	24

View of brace



◉ = TK / HI.FORCE
Washer head partial thread

● = VG / IN.FORCE
Cylindrical head full thread

Table 9.5 Execution with 6 mm TK / HI.FORCE and 6 mm VG / IN.FORCE

For all combinations the screw lengths have to be selected in such a way that the screw tips of opposite head bands in the post do not touch. Exception Tab. 9.5 Dimension D4-E4, here the tips mathematically cross by a max. of 2 mm.

	A	B	C	D	E	F	G	H	I	J	K
1				Post width or frame height [mm]							
2				95		100		120		140	
3				d_1	Ls	d_1	Ls	d_1	Ls	d_1	Ls
4	Brace height [mm]	95	VG / IN.FORCE	6.0	140	6.0	140				
5			Dimension b [mm]	75		72					
6		100	VG / IN.FORCE			6.0	160	6.0	160	6.0	180
7			Dimension b [mm]			90		80		85	
8		120	VG / IN.FORCE			6.0	180	6.0	180	6.0	200
9			Dimension b [mm]			110		100		105	
10		140	VG / IN.FORCE			6.0	180	6.0	200	6.0	200
11			Dimension b [mm]			110		120		105	
12	For all combinations TK / HI.FORCE 6.0x140 mm, with spacing a = 70 mm										

Table 9.6 Execution with 8 mm TK / HI.FORCE and 8 mm VG / IN.FORCE

	A	B	C	H	I	J	K
1				Post width or frame height [mm]			
2				120		140	
3				d_1	Ls	d_1	Ls
8	Brace height [mm]	120	VG / IN.FORCE	8.0	180	8.0	200
9			Dimension b [mm]	100		105	
10		140	VG / IN.FORCE	8.0	200	8.0	220
11			Dimension b [mm]	120		120	
12	For all combinations TK / HI.FORCE 8.0x160 mm, with spacing a = 80 mm						

9. Further examples

You can find further examples and technical information in the following SPAX wood construction reports. You can find these in our download portal: downloads.spax.com.

Wood construction report No. 1
Wooden roller coaster in Sweden, gap reinforcement with SPAX full-thread screws

Wood construction report No. 2
Attic extension in a single-family house, connection of a collar beam to a middle purlin with SPAX full-thread screws

Wood construction report No. 3A
Transverse pressure reinforcement for a girder support with SPAX full-thread screws

Wood construction report No. 3B
Transverse pressure reinforcement for a girder support with SPAX full-thread screws

Wood construction report No. 3C
Transverse pressure reinforcement for a girder support with SPAX full-thread screws

Wood construction report No. 4A
Notch reinforcement for a beam support with SPAX full-thread screws

Wood construction report No. 5A
Transverse tension reinforcement via SPAX full-thread screws to connect main and secondary beams with shaped sheet metal parts (cross connections)

Wood construction report No. 6
Pre-drilling SPAX correctly - points to observe

Wood construction report No. 7
Chock connection with SPAX full-thread screws

Wood construction report No. 8
Purlin-post connection with SPAX full-thread screws

Wood construction report No. 9
Transverse pressure reinforcement for SIMPSON Strong-Tie top connector EL for unfavourable a/H ratio with SPAX full-thread screws

Wood construction report No. 10
Transverse pressure reinforcement for sheet metal-to-wood bolted connections

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Notes:

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