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Authorised and notified according to Article 29 of the Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011

MEMBER OF EOTA

European Technical Assessment ETA-23/0670 of 2025/01/24

I General Part

Technical Assessment Body issuing the ETA and designated according to Article 29 of the Regulation (EU) No 305/2011: ETA-Danmark A/S

Trade name of the construction product:	Knapp WALCO Bolt and WALCO Pipe connectors
Product family to which the above construction product belongs:	Three-dimensional nailing plate
Manufacturer:	Knapp GmbH Wassergasse 31 A-3324 Euratsfeld Tel.: +43 (0) 7474 79910-0 Telefax: +43 (0) 7474 79910-99 Internet: www.knapp-verbinder.com
Manufacturing plant:	Knapp GmbH Wassergasse 31 A-3324 Euratsfeld
This European Technical Assessment contains:	36 pages including 3 annexes which form an integral part of the document
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of:	EAD 130186-00-0603, Three Dimensional Nailing Plates.
This version replaces:	The ETA with the same number issued on 2023-09-25

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II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product

Knapp WALCO Bolt and WALCO Pipe connectors are two-piece (WALCO Bolt) or one-piece (WALCO Pipe), face-fixed connectors to be used in timber-to-timber connections.

The plates of the WALCO Bolt connectors are made from steel grade DD13 according to EN 10111 with minimum yield strength R_e of 235 MPa. The corresponding bolts are made from steel grade 1.0718 according to EN 10277-1.

The WALCO Pipe connectors are made from steel grade E235+C according to EN 10305-1. The corresponding bolts are made from steel grade 1.0718 according to EN 10277-1.

Dimensions, hole positions and typical installations are shown in Annex A.

2 Specification of the intended use in accordance with the applicable European Assessment Document (hereinafter) EAD

The connectors are intended for use in making end-grain to side-grain connections, end-grain to end-grain and side-grain to side-grain connections in load bearing timber structures, as a connection between two wood-based members, where requirements for mechanical resistance and stability and safety in use in the sense of the Basic Works Requirements 1 and 4 of Regulation (EU) 305/2011 shall be fulfilled.

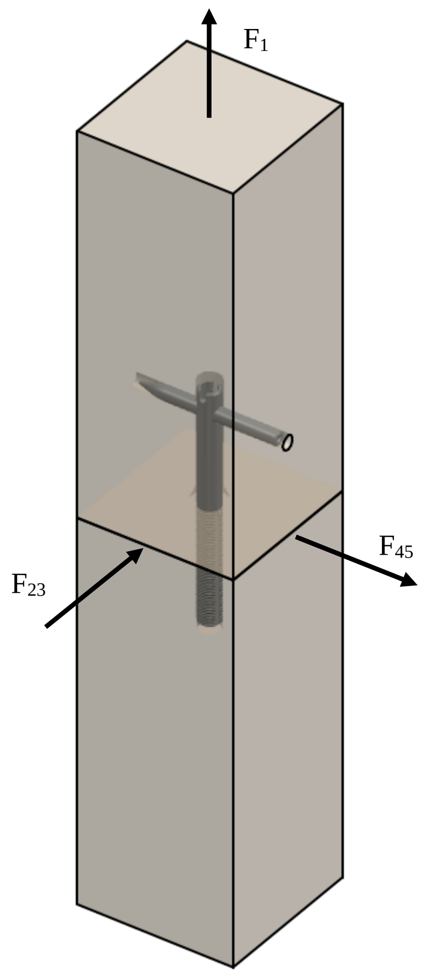
The connectors can be installed as connections between wood-based members such as:

- Structural solid timber of softwood according to EN 338 / EN 14081,
- Glued solid timber of softwood according to EN 14080,
- Glulam made of softwood, classified according to EN 14080 or ETA
- LVL according to EN 14374 or ETA
- Cross laminated timber and similar structural glued products according to EN 16351 or ETA.

However, the calculation methods are only allowed for a characteristic wood density of up to 460 kg/m^3. Even though the wood-based material may have a larger density, this must not be used in the formulas for the load-carrying capacities of the fasteners.

Annex B states the formulas for the characteristic load-carrying capacities of the connections. The design of the connections shall be in accordance with Eurocode 5 or a similar national Timber Code.

It is assumed that the forces acting on the connection are the following F_1, F_{23} and F_{45}. The force F_1 acts perpendicular to the joint plane between the timber members in the direction of insertion, F_{23} and F_{45} shall act parallel to the joint plane between the timber members and perpendicular to the direction of insertion. It is assumed that the forces are acting right in the joint line between the timber members.



It is assumed that the timber members are prevented from rotating.

The connectors are intended for use in connections subject to static or quasi static loading. The zinc-coated connectors are for use in timber structures subject to dry, internal conditions defined by the service classes 1 and 2 of EN 1995-1-1, (Eurocode 5). The fasteners (screws and bolts) to be used shall be made from suitable material.

Details of the corrosion protection system are deposited at ETA-Danmark.

The scope of the connectors regarding resistance to corrosion shall be defined according to national provisions that apply at the installation site considering environmental conditions.

The provisions made in this European Technical Assessment are based on an assumed intended working life of the connectors of 50 years.

The indications given on the working life cannot be interpreted as a guarantee given by the producer or Assessment Body but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

Characteristic	**Assessment of characteristic**
3.1 Mechanical resistance and stability*) (BWR1)	
Joint Strength - Characteristic load-carrying capacity	See Annex B
Joint Stiffness	See Annex B
Joint ductility	No performance assessed
Resistance to seismic actions	No performance assessed
Resistance to corrosion and deterioration	See section 3.6
3.2 Safety in case of fire (BWR2)	
Reaction to fire	The concealed connectors are made from steel classified as Euroclass A1 in accordance with EN 13501-1 and Commission Delegated Regulation 2016/364
Resistance to fire	No performance assessed
3.3 General aspects related to the performance of the product	The concealed connectors have been assessed as having satisfactory durability and serviceability when used in timber structures using the timber species described in Eurocode 5 and subject to the conditions defined by service class 1, 2 and 3
Identification	See Annex A

*) See additional information in section 3.7 – 3.10.

3.7 Methods of verification

The characteristic load-carrying capacities are based on the characteristic values of the connectors and the steel plates.

According to EN 1990 (Eurocode – Basis of design) paragraph 6.3.5 the design value of load-carrying capacity can be determined by reducing the characteristic values of the load-carrying capacity with different partial factors.

Therefore, to obtain design values according to the Eurocodes or appropriate national codes of practice, the capacities must be multiplied with different partial factors for the material properties and the coefficient k_{mod} that takes into account the load duration class.

Thus, the characteristic or design values of the load–carrying capacity are determined for timber failure $F_{Rk,H}$ (obtaining the embedment strength of connectors subjected to shear or the withdrawal capacity of the most loaded connector, respectively (see Annex B). The design value of the load–carrying capacity is:

$$F_{Rd} = \frac{k_{mod} \cdot F_{Rk}}{\gamma_M}$$

Therefore, the load duration class and the service class are included.

3.8 Mechanical resistance and stability

See annex B for characteristic load-carrying capacities of the connectors.

The characteristic capacities of the connectors are determined by calculation assisted by testing as described in the EAD 130186-00-0603. They should be used for designs in accordance with Eurocode 5 or a similar national Timber Code.

The design models allow the use of fasteners described in Annex A:

Screws in accordance with EN 14592
In the formulas in Annex B the capacities for self-drilling screws calculated from the formulas of Eurocode 5 are used when calculating the axial load-carrying-capacity.

Further, the connectors can be fastened to a steel member by dowels with a diameter of 10 to 18 mm in holes with a diameter up to 1 mm larger than the dowel.

No performance has been determined in relation to ductility of a joint under cyclic testing. The contribution to the performance of structures in seismic zones, therefore, has not been assessed.

3.9 Aspects related to the performance of the product

3.5.1 Corrosion protection in service class 1 and 2.
In accordance with EAD 130186-00-0603 the connectors from mild steel either have a zinc coating weight of min Z275 or an equivalent coating Fe/Zn 12. The steel employed is DD13 according to EN 10111:2008-06 with minimum yield strength R_e of 235 MPa or E235+C according to EN 10305:2016-08.

3.10 General aspects related to the fitness for use of the product

Knapp WALCO Bolt or WALCO Pipe Connectors are manufactured in accordance with the provisions of this European Technical Assessment using the manufacturing processes as identified in the inspection of the plant by the notified inspection body and laid down in the technical documentation.

Connector joints

A connector joint is deemed fit for its intended use provided:

- The timber members shall be restrained against rotation and be free from wane under the connector.
- Connectors are fastened to wood-based members by screws or threaded rods or inserts or bolts .
- There shall be screws in all marked holes as prescribed in Annex A.
- The characteristic capacity of the connector joint is calculated according to the manufacturer’s technical documentation, dated 2023-05-31 and 2024-07-16
- The connector joint is designed in accordance with Eurocode 5 or an appropriate national code.
- There is no gap between the timber member surface and the connector plate or between the timber member surfaces.
- For Knapp WALCO Bolt and WALCO Pipe connectors the width of the timber member be at least the minimum width as given in Annex A or C.
- The cross section of the timber at the connector joint shall have sharp edges, it shall be without wane.
- The depth of the timber member shall be so large that the minimum fastener end and edge distances are observed.
- Screws to be used shall have a diameter, which fits the holes of the connector plates.
- The screws shall be driven into softwood after pre-drilling.

4 Assessment and verification of constancy of performance (AVCP) (hereinafter AVCP) system applied, with reference to its legal base.

4.1 AVCP system

According to the decision 97/638/EC of the European Commission1, as amended, the system(s) of assessment and verification of constancy of performance (see Annex V to Regulation (EU) No 305/2011) is 2+.

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at ETA-Danmark prior to CE marking.

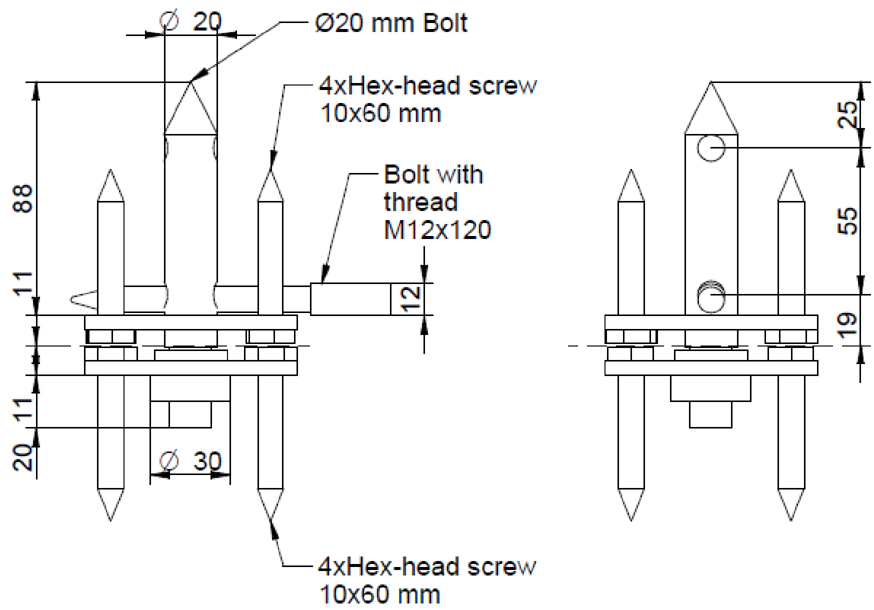
Issued in Copenhagen on 2025-01-24 by

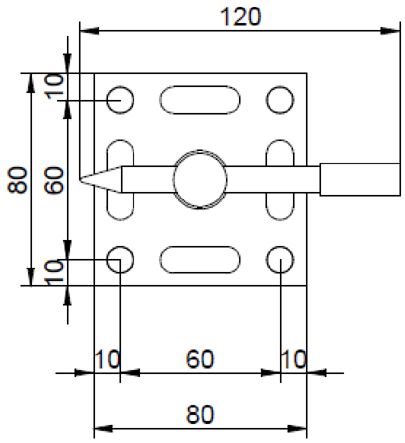
Thomas Bruun
Managing Director, ETA-Danmark

Annex A
Product details and definitions

KNAPP WALCO Bolt A130

5.0 mm thick steel, grade DD13 according to EN 10111, with yield strength R_e of 235 MPa.
Pre-galvanized steel plate with coating Fe/Zn 12

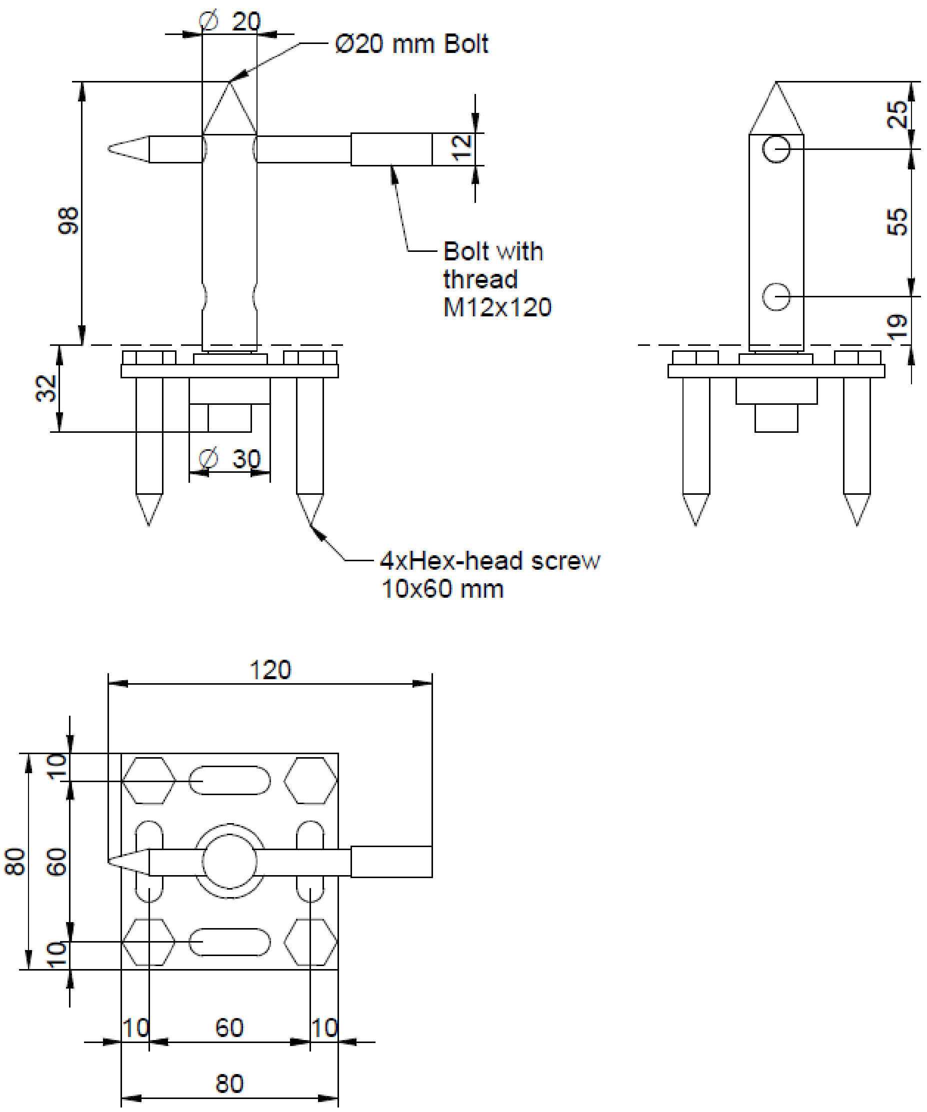




4 screws per plate, with KNAPP® WALCO® V PH screw 10x60

KNAPP WALCO Bolt B130

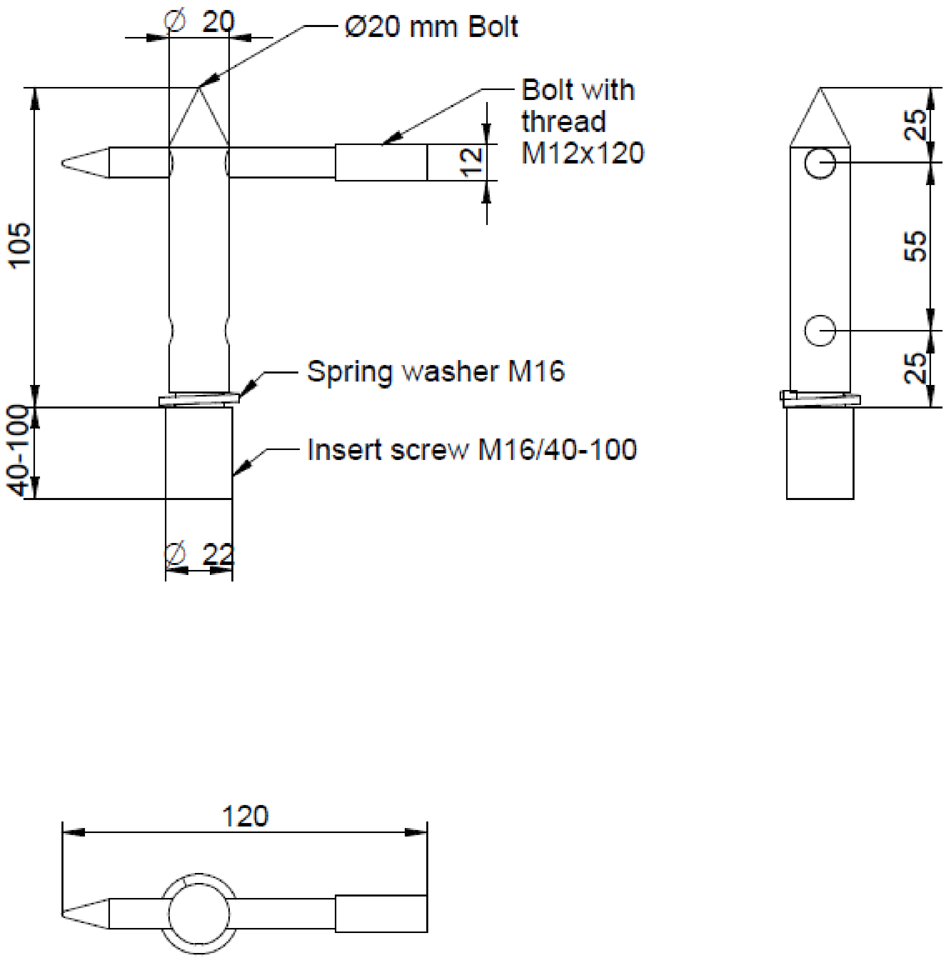
5.0 mm thick steel, grade DD13 according to EN 10111, with yield strength R_e of 235 MPa.
Pre-galvanized steel plate with coating Fe/Zn 12



4 screws per plate, with KNAPP® WALCO® V PH screw 10x60

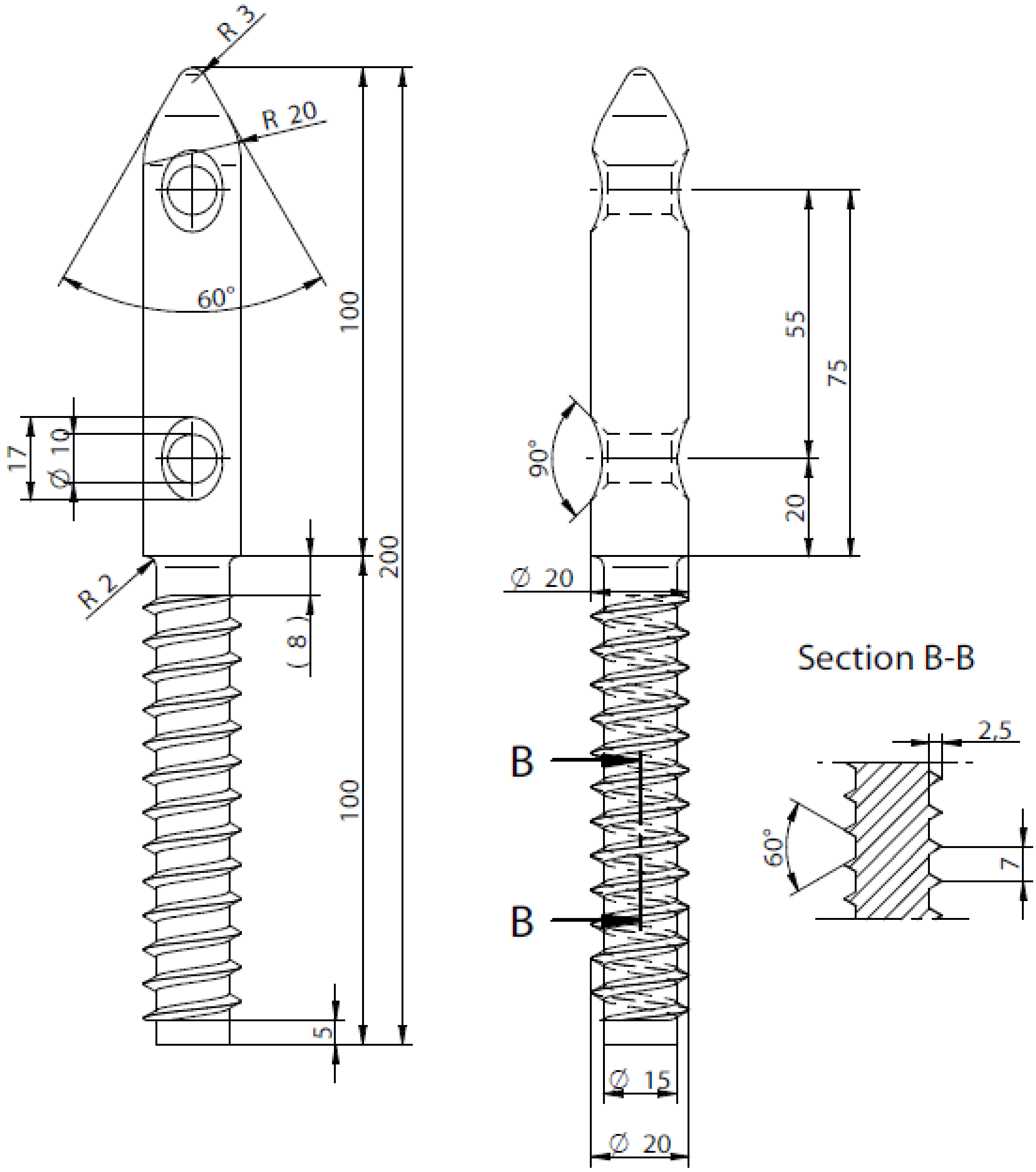
KNAPP WALCO Bolt C130

20.0 mm Bolt with RAMPA insert according to ETA-12/0481



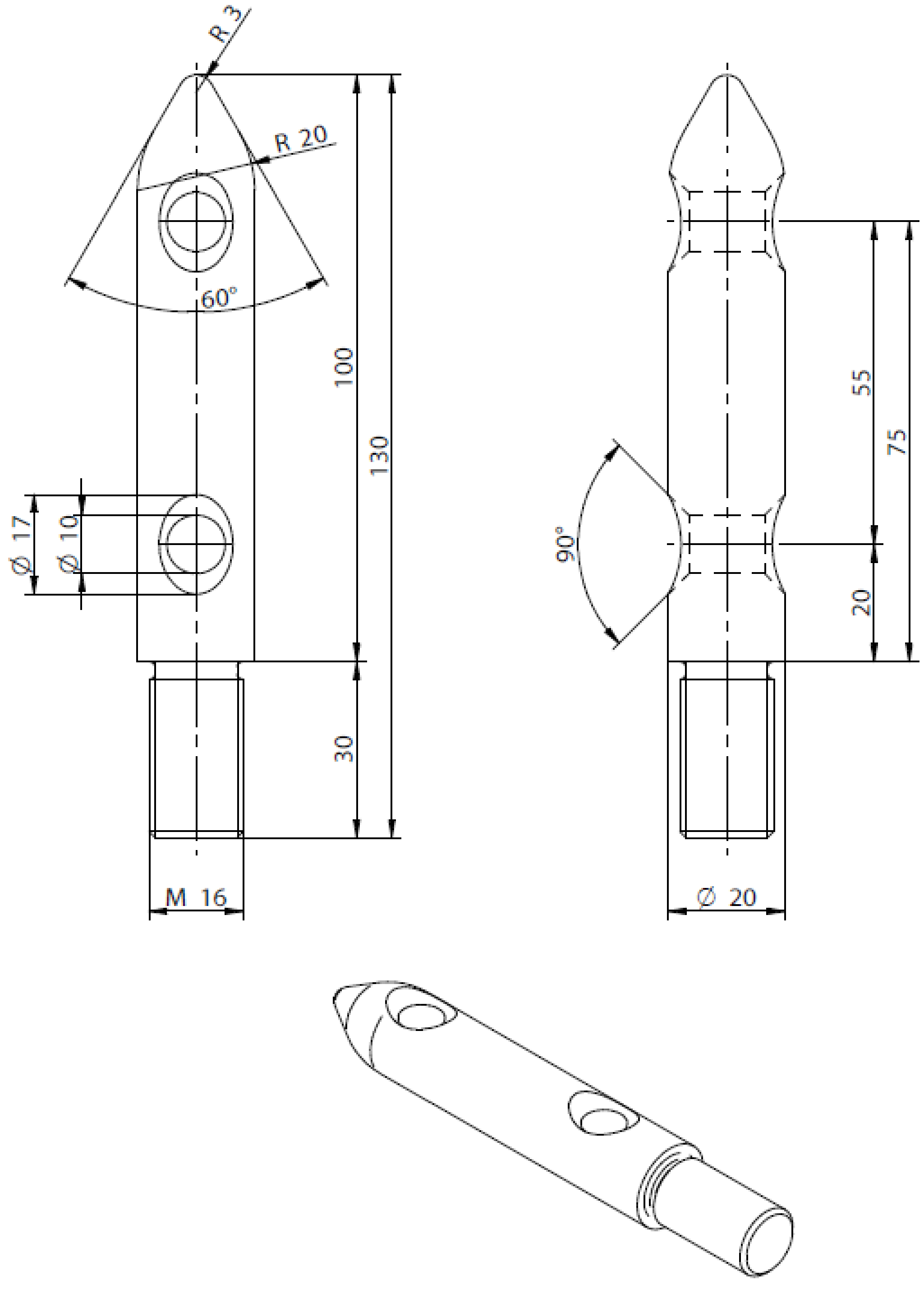
KNAPP® WALCO® Bolt D130

D 20.0 mm bolt with 100mm wooden thread on the bottom, steel grad 11 SMnPb30 B 45/30 (material No. 1.0718) according to EN 10277-1
Pre-galvanized steel plate with coating Fe/Zn 12



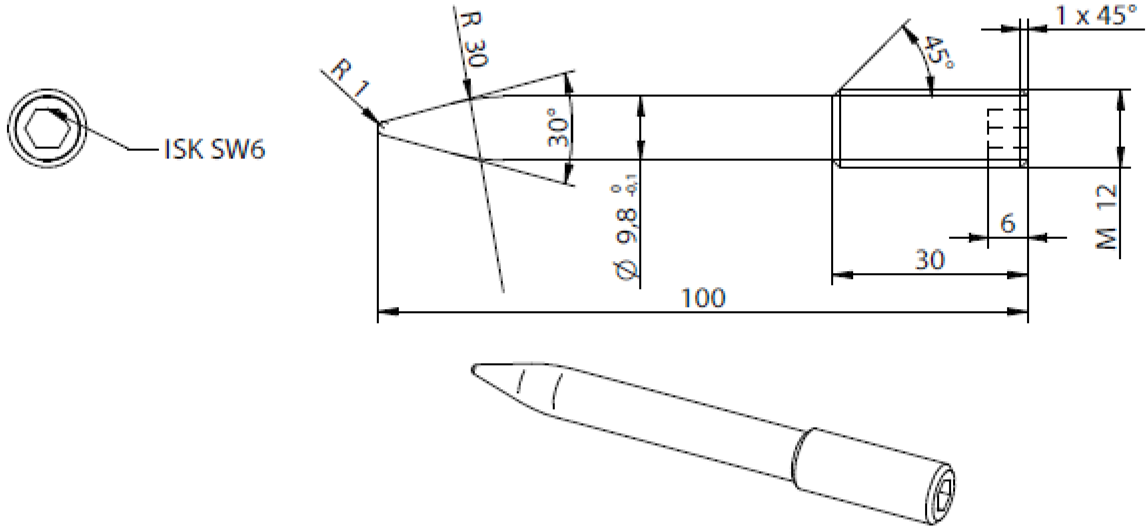
KNAPP® WALCO® Bolt

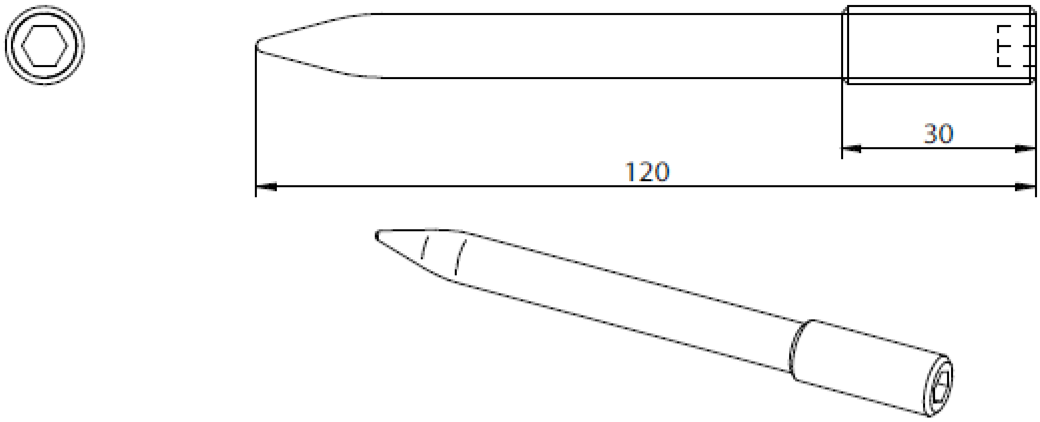
D 20.0 mm bolt with M16x30 mm thread on the bottom, steel grad 11 SMnPb30 B 45/30 (material No. 1.0718) according to EN 10277-1
Pre-galvanized steel plate with coating Fe/Zn 12

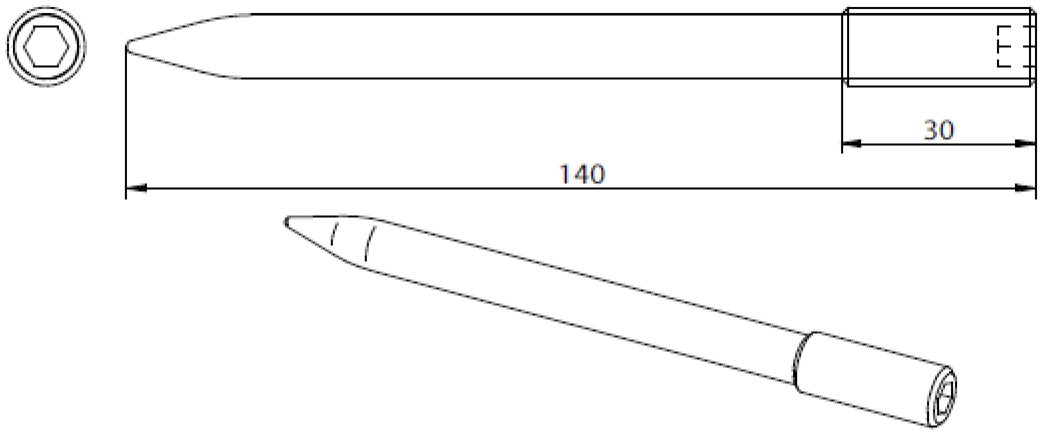


KNAPP® WALCO® Bolt

D 10.0 mm blank clamping bolt with M12x30 mm thread on the end, steel grad 11 SMnPb30 B 45/30 (material No. 1.0718) according to EN 10277-1
Pre-galvanized steel plate with coating Fe/Zn 12



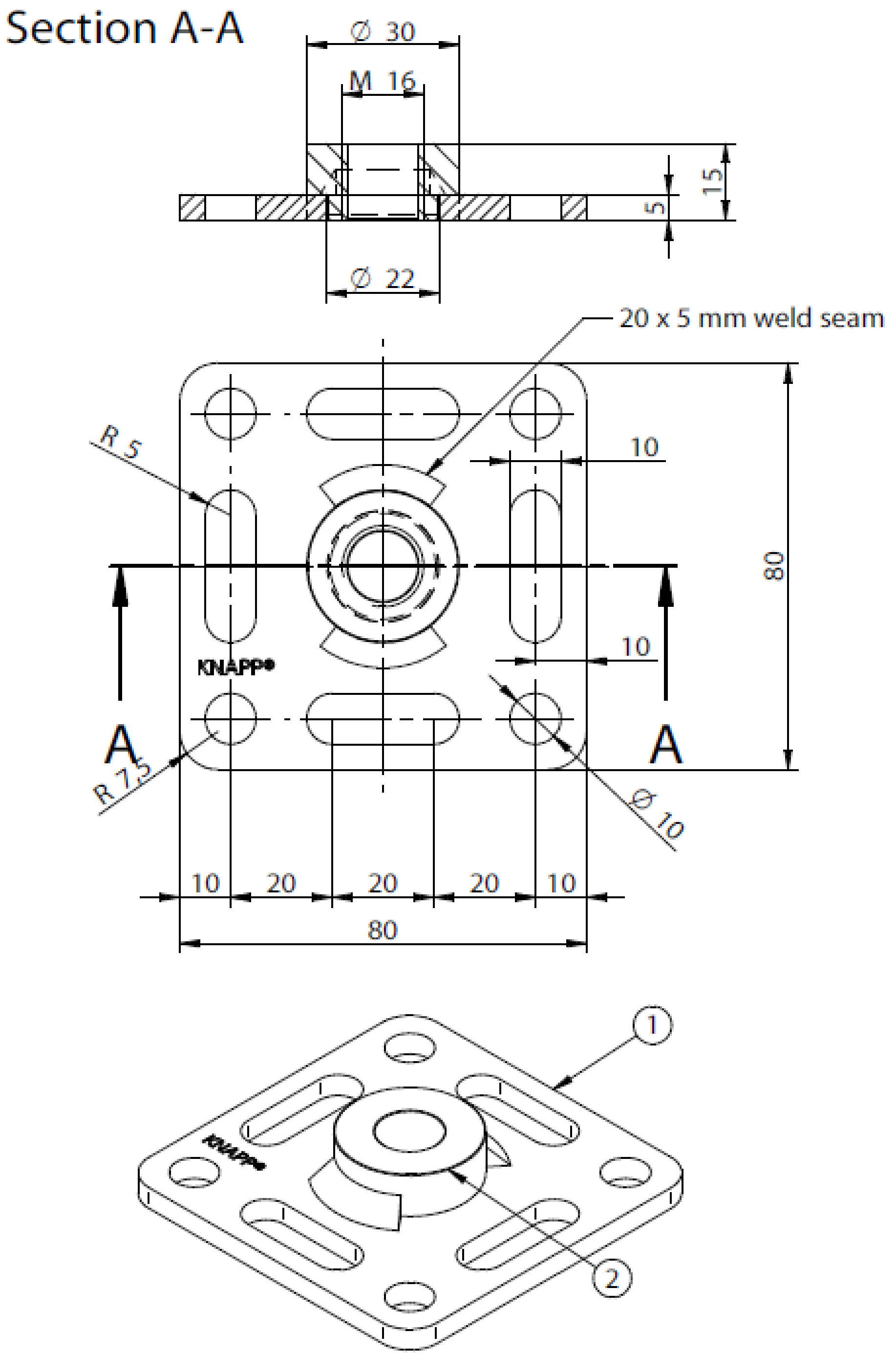




KNAPP® WALCO® 80 Bolt connector plate with welded M16 threaded sleeve

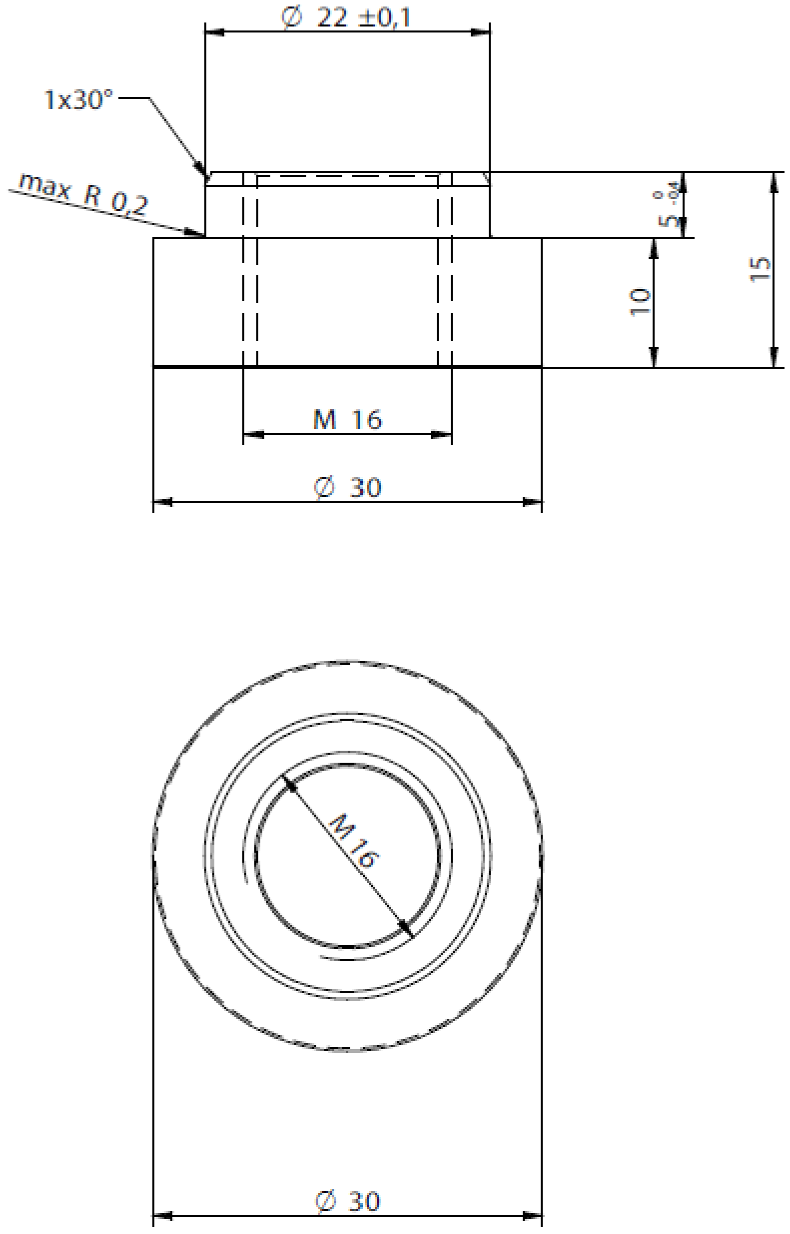
5.0 mm thick steel grade DD13 according to EN 10111:2008-06 with minimum yield strength Re of 235 MPa;

M16 threaded sleeve of pre-galvanized steel grade 16MnCrS5 according to EN 10277-4 with HBW values 156-20
Corrosion protection according to Eurocode 5-1-1



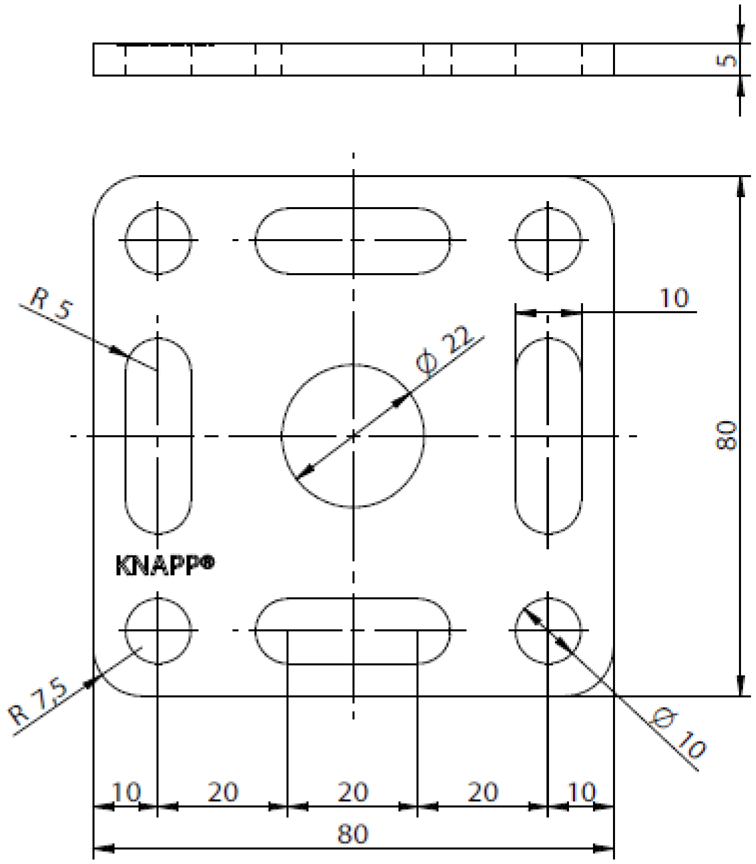
KNAPP® WALCO® Bolt threaded sleeve for WALCO® 80 base plate

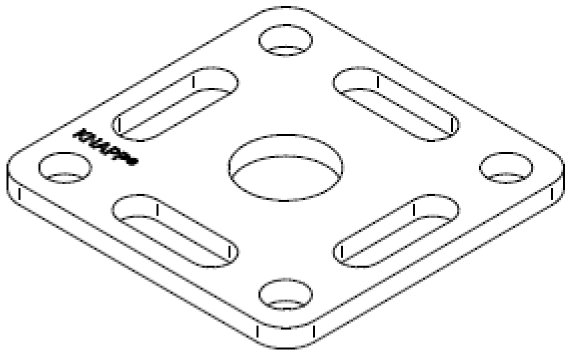
M16 threaded sleeve of pre-galvanized steel grade 16MnCrS5 according to EN 10277-4 with HBW values 156 - 207
Corrosion protection according to Erocode 5-1-1 (>5µm zinc coating)



KNAPP® WALCO® 80 Bolt base plate

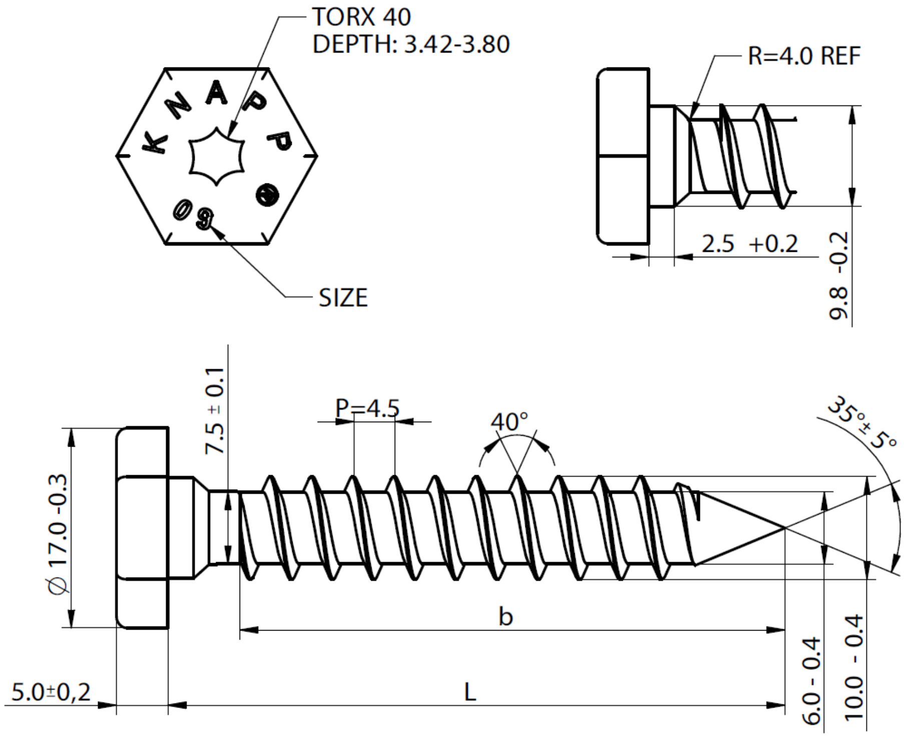
5.0 mm thick steel grade DD13 according to EN 10111:2008-06 with minimum yield strength R_e of 235 MPa; Corrosion protection according to Eurocode 5-1-1





KNAPP® WALCO® V PH screw 10x60, 10x100

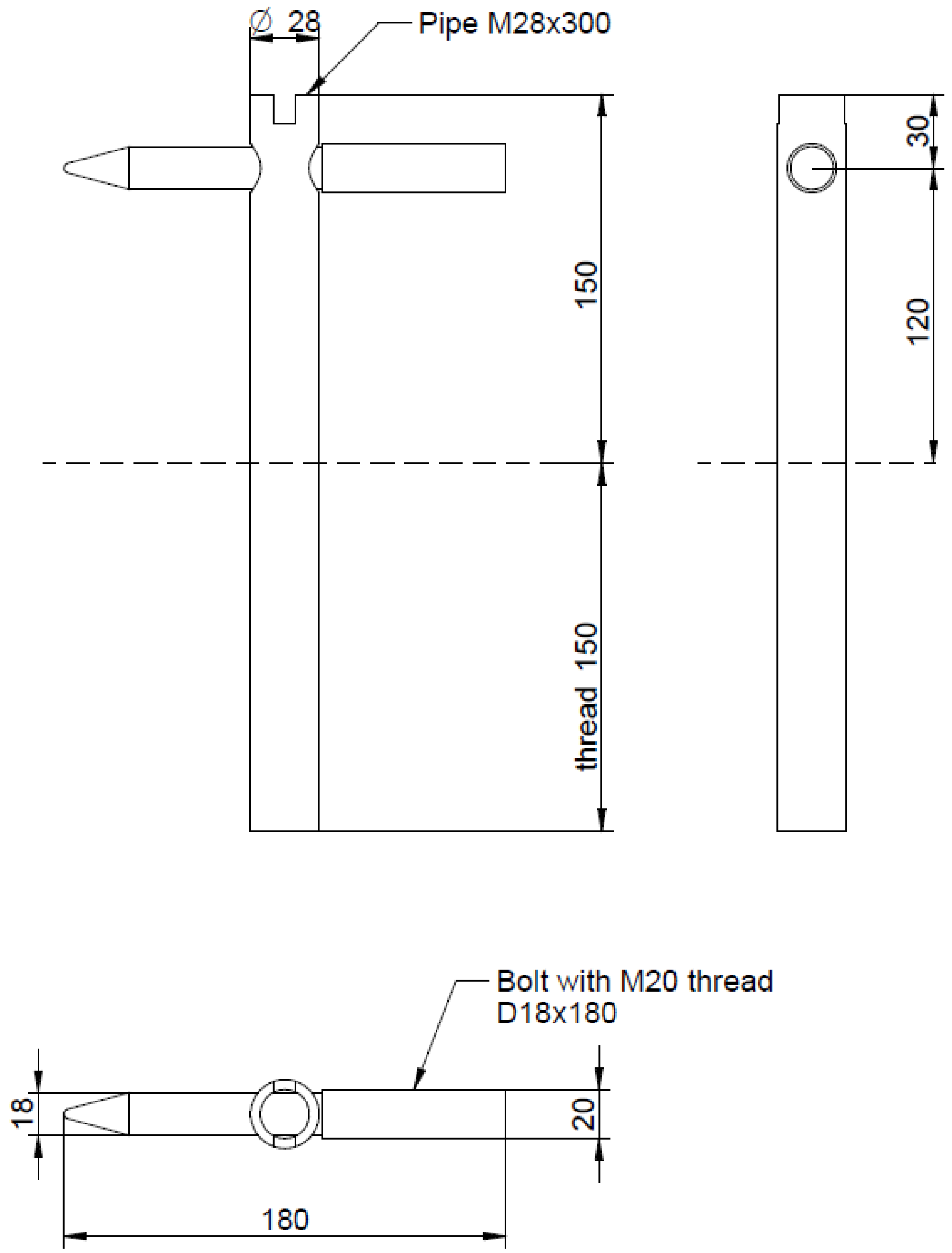
Screws according to EN 14592 manufactured of carbon steel, tension $f_{tens,k}$ of 24 kN, yield moment $M_{y,Rk}$ of 36 Nm and torque $M_{t,u,k}$ of 40 Nm;
corrosion protection according to EN 1995-1-1;



L	60 – 1,5	100 – 3,5
b	50 ±1,0	90 ±1,0

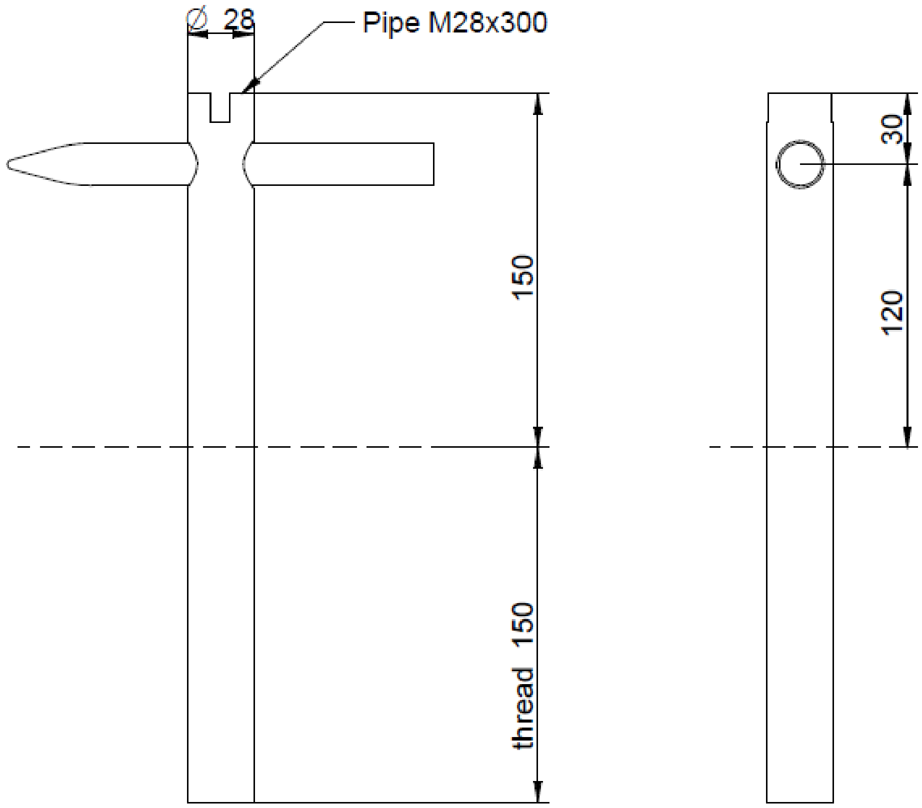
KNAPP WALCO Pipe A300

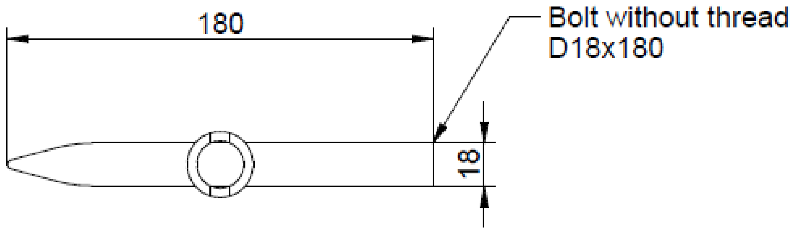
4.0 mm thick steel, grade E235+C according to EN 10305.
Pre-galvanized steel plate with coating Fe/Zn 12



KNAPP WALCO Pipe B300

4.0 mm thick steel, grade E235+C according to EN 10305.
Pre-galvanized steel plate with coating Fe/Zn 12

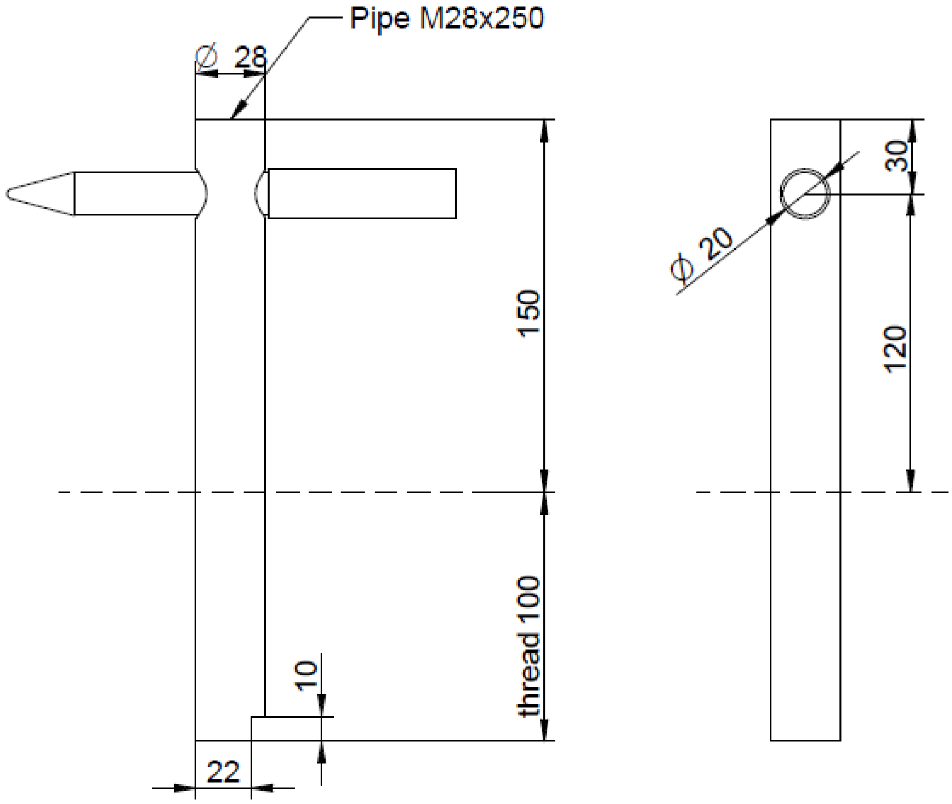


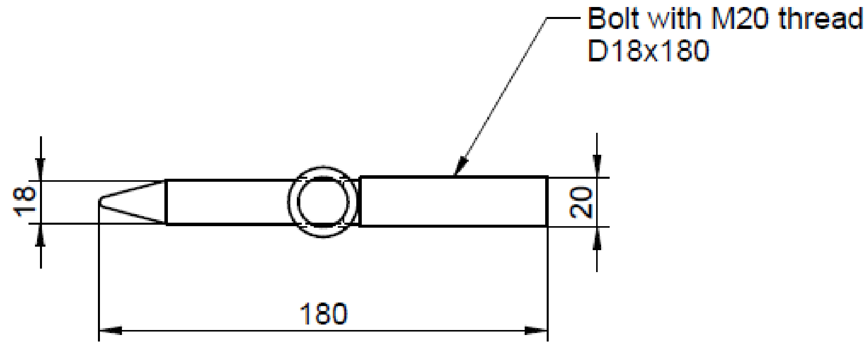


4 screws per plate, with KNAPP® WALCO® V PH screw 10x60

KNAPP WALCO Pipe C300

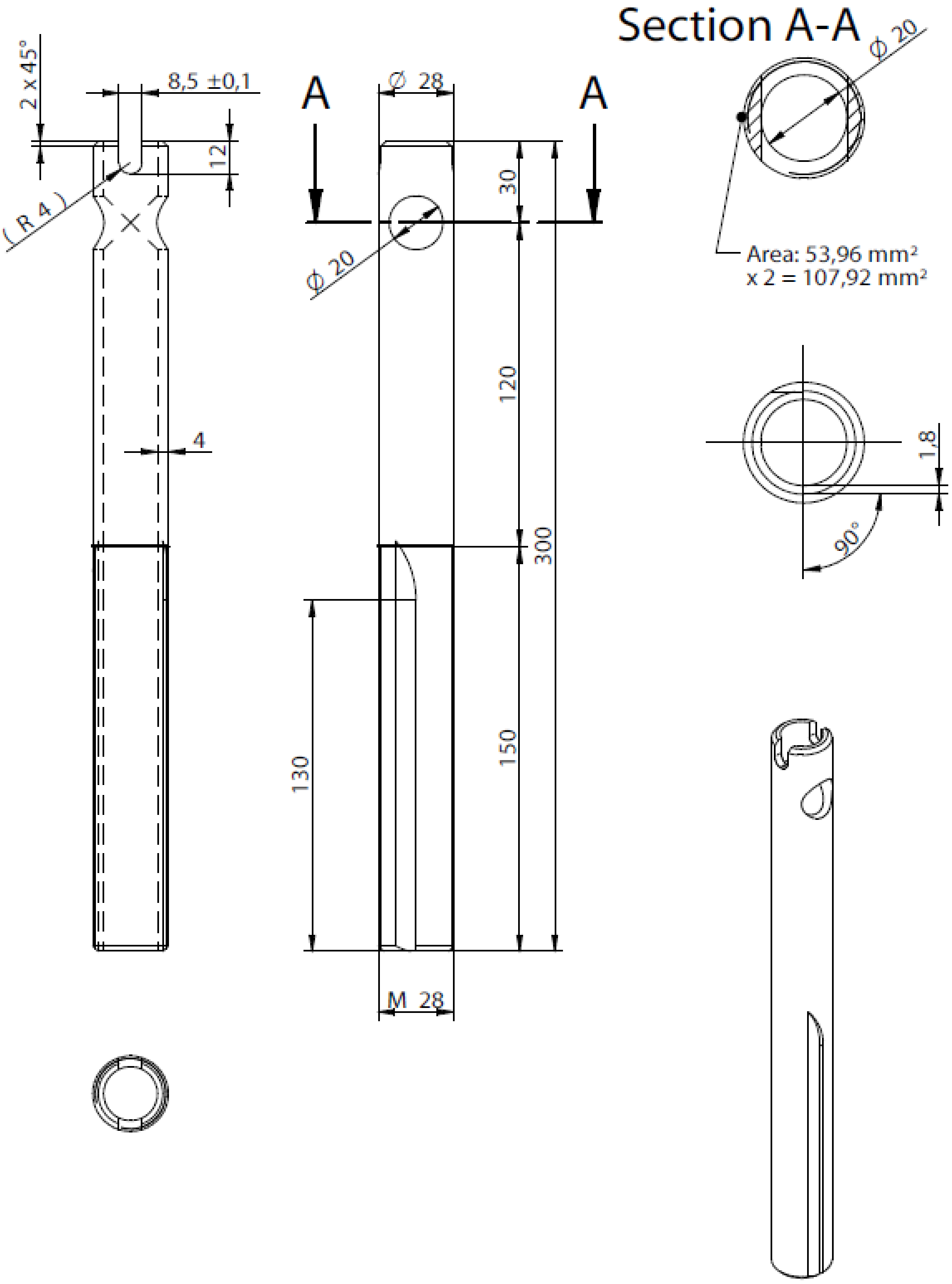
4.0 mm thick steel, grade E235+C according to EN 10305.
Pre-galvanized steel plate with coating Fe/Zn 12





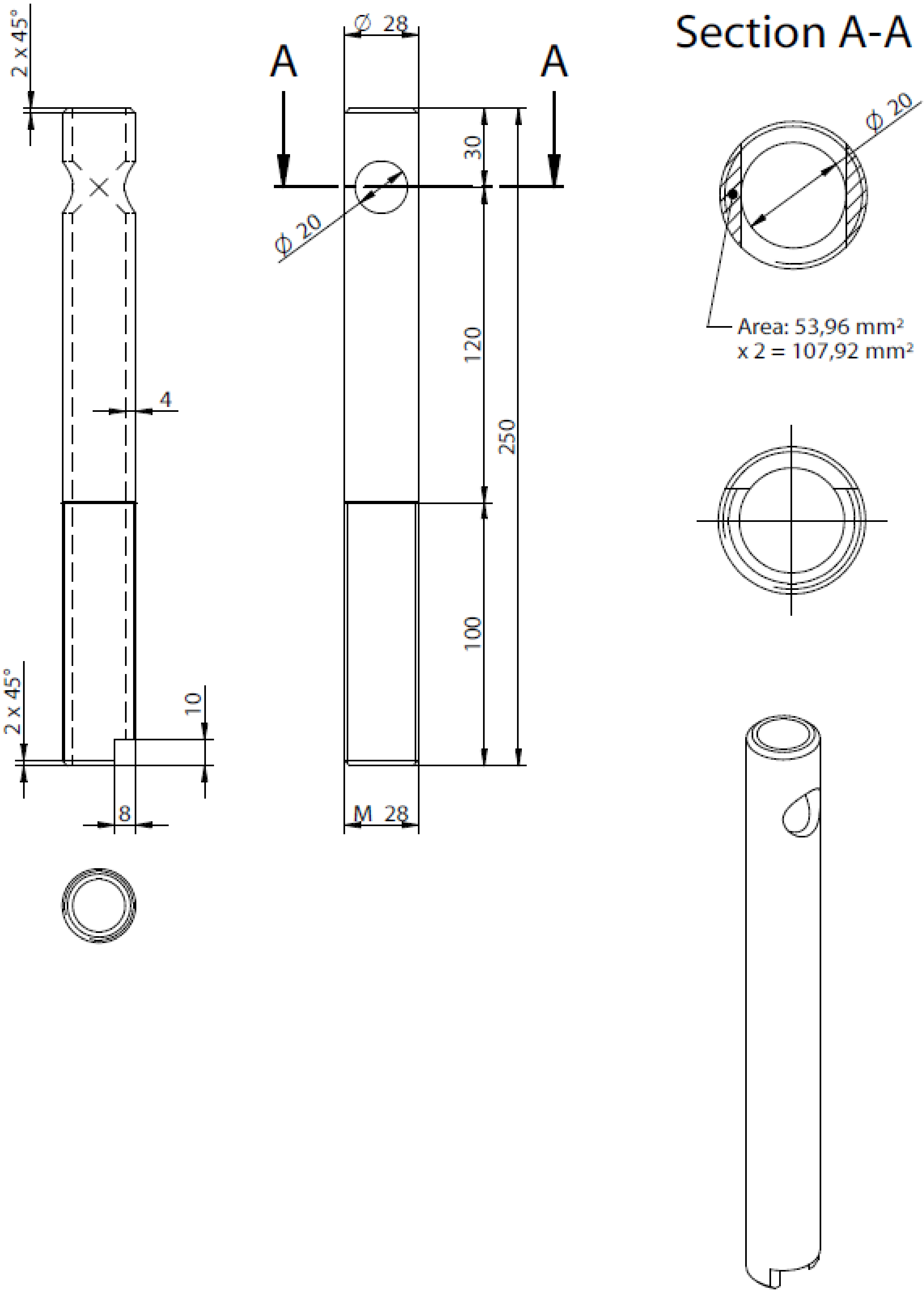
KNAPP® WALCO® PIPE A300

D 28.0 mm and 4 mm thick precision steel pipe with M28x150 mm thread on the bottom, steel grad E 235+C according to EN10305-1: 2016-08
Pre-galvanized steel plate with coating Fe/Zn 12



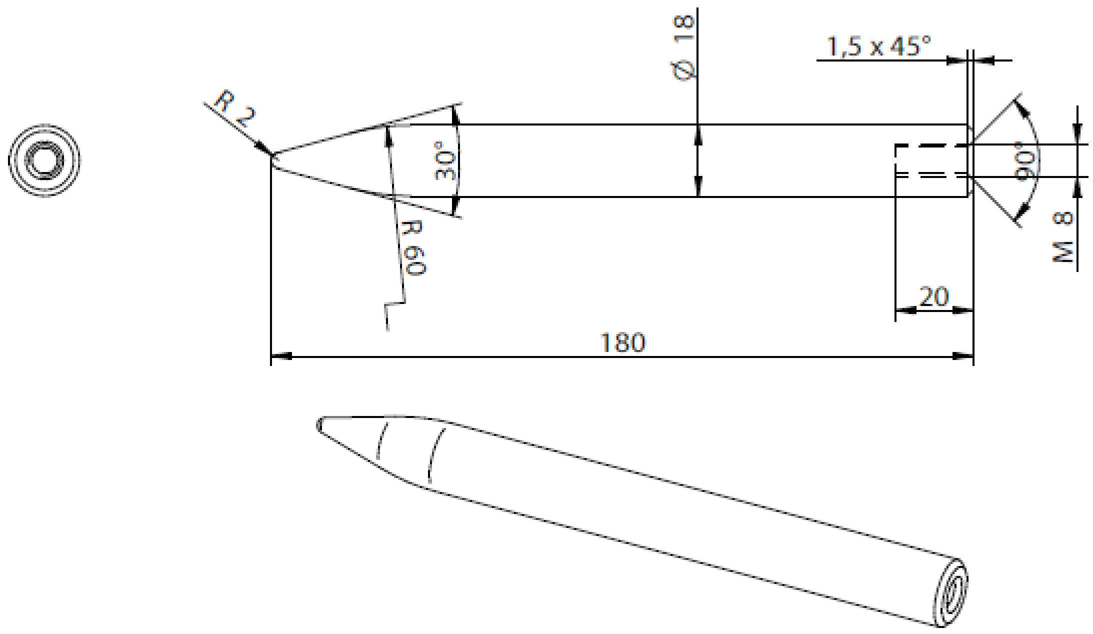
KNAPP® WALCO® PIPE C250

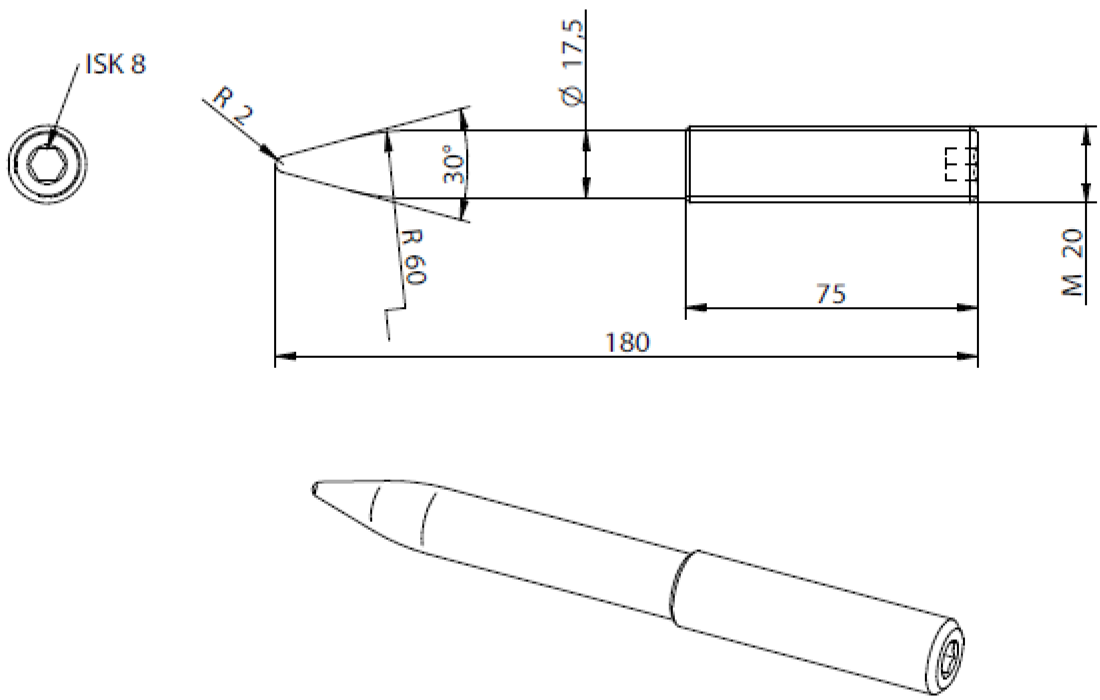
D 28.0 mm and 4 mm thick precision steel pipe with M28x100 mm thread on the bottom, steel grad E 235+C according to EN10305-1: 2016-08
Pre-galvanized steel plate with coating Fe/Zn 12



KNAPP® WALCO® PIPE

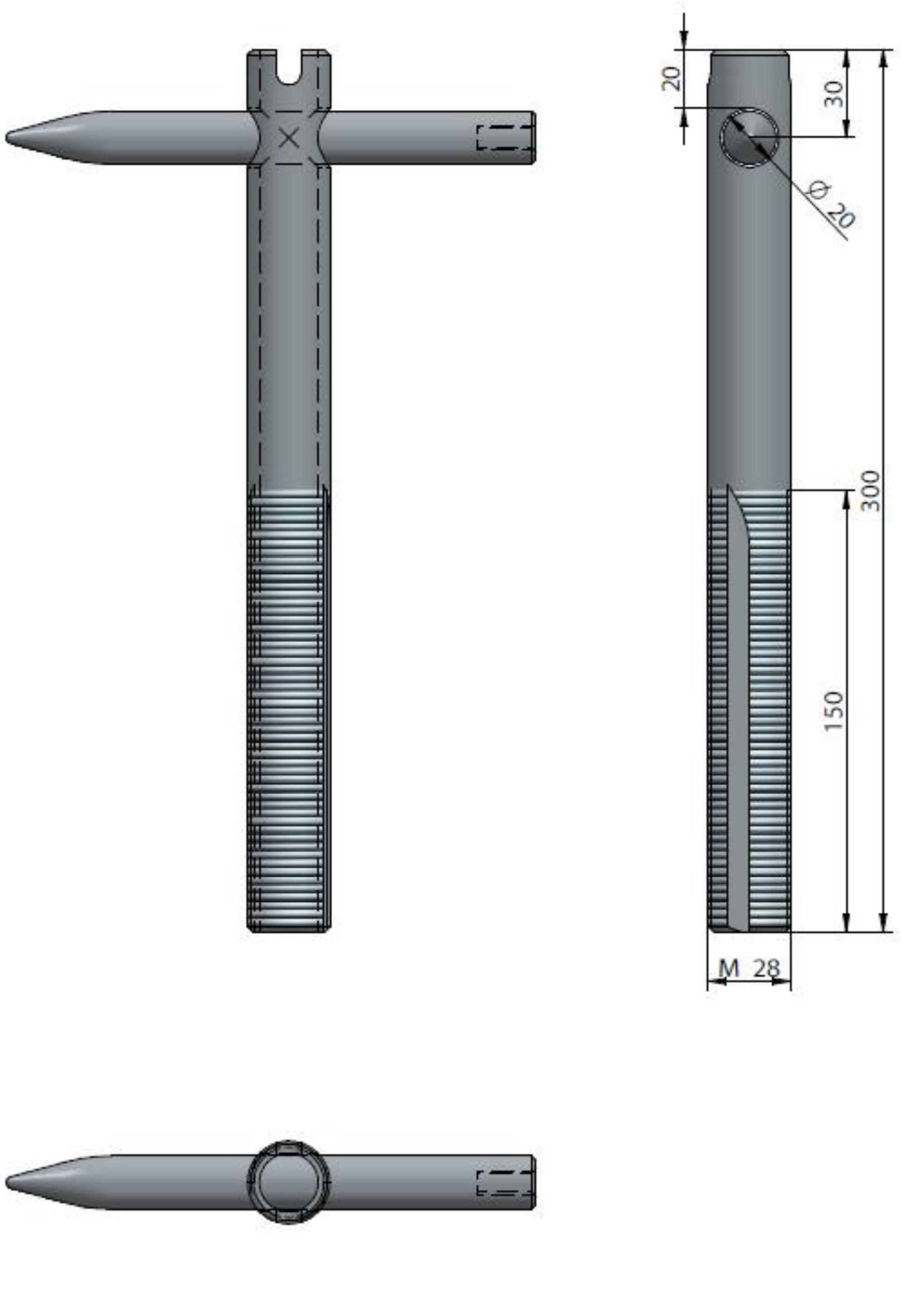
D 18.0 mm blank clamping bolt with M20x75 mm thread on the end / without thread, steel grad 11 SMnPb30 B 45/30 (material No. 1.0718) according to EN 10277-1
Pre-galvanized steel plate with coating Fe/Zn 12





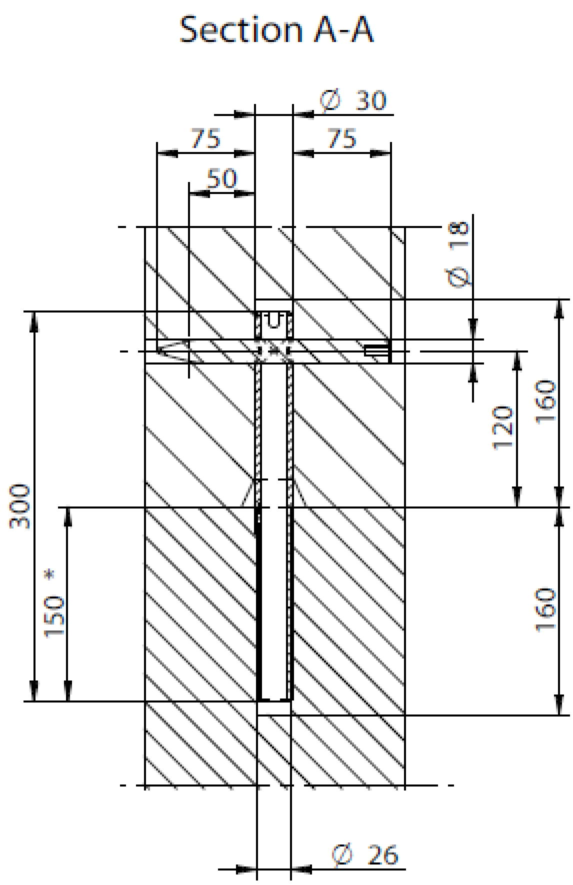
KNAPP® WALCO® PIPE A300

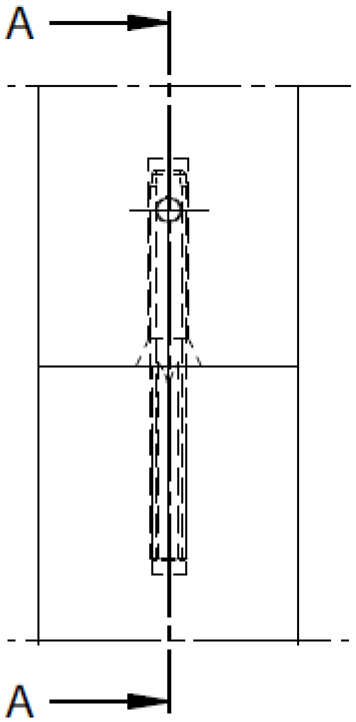
WALCO PIPE A300 Assembly drawing with inserted blank clamping bolt D18x180 mm

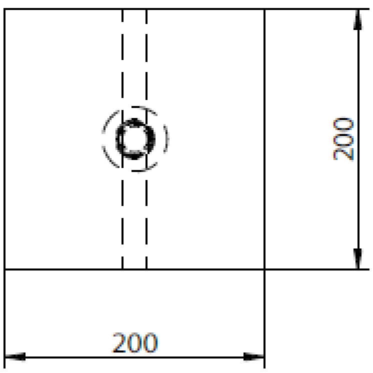


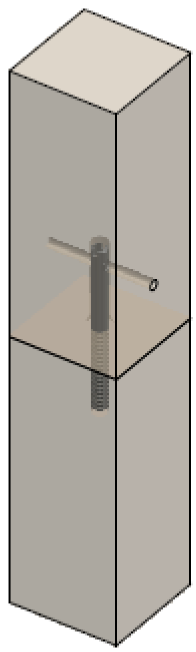
KNAPP® WALCO® PIPE A300

WALCO PIPE A300 Installation drawing in 2 wooden components with inserted clamping bolts D18x180 mm







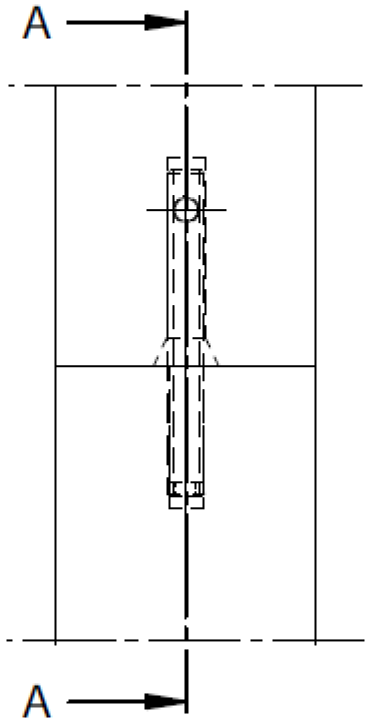


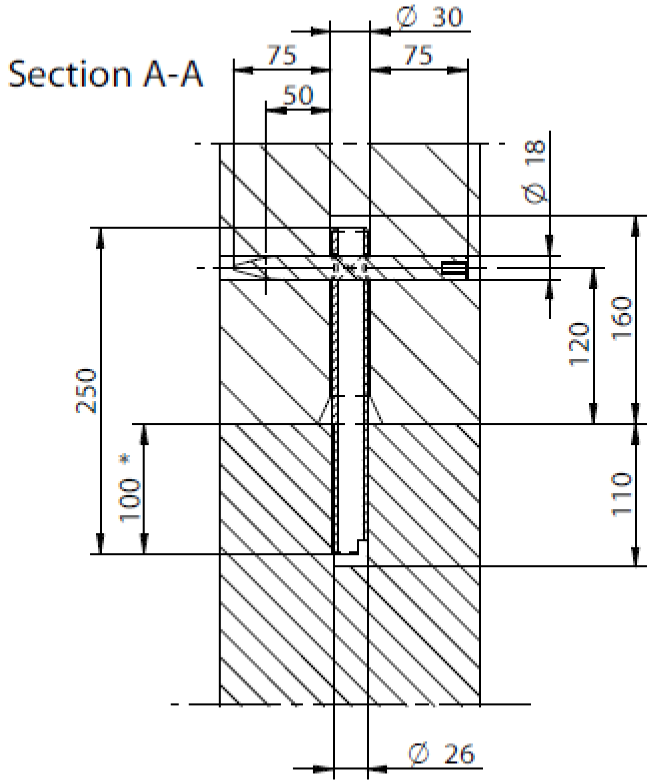
* ... The strength of the component bracing can be adjusted with the insertion depth

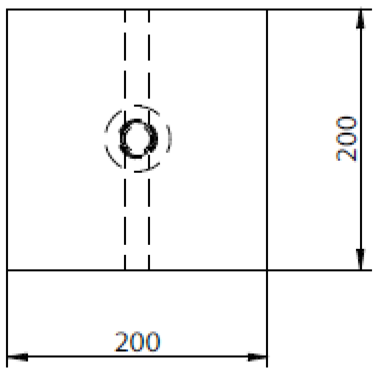
Thread pitch 3 mm

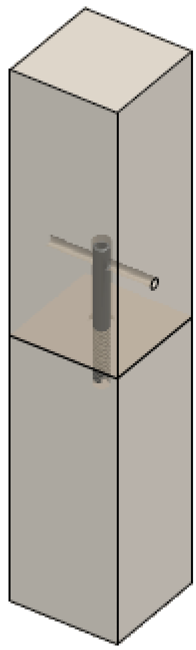
KNAPP® WALCO® PIPE C250

WALCO PIPE C250 Installation drawing in 2 wooden components with inserted clamping bolts D18x180 mm







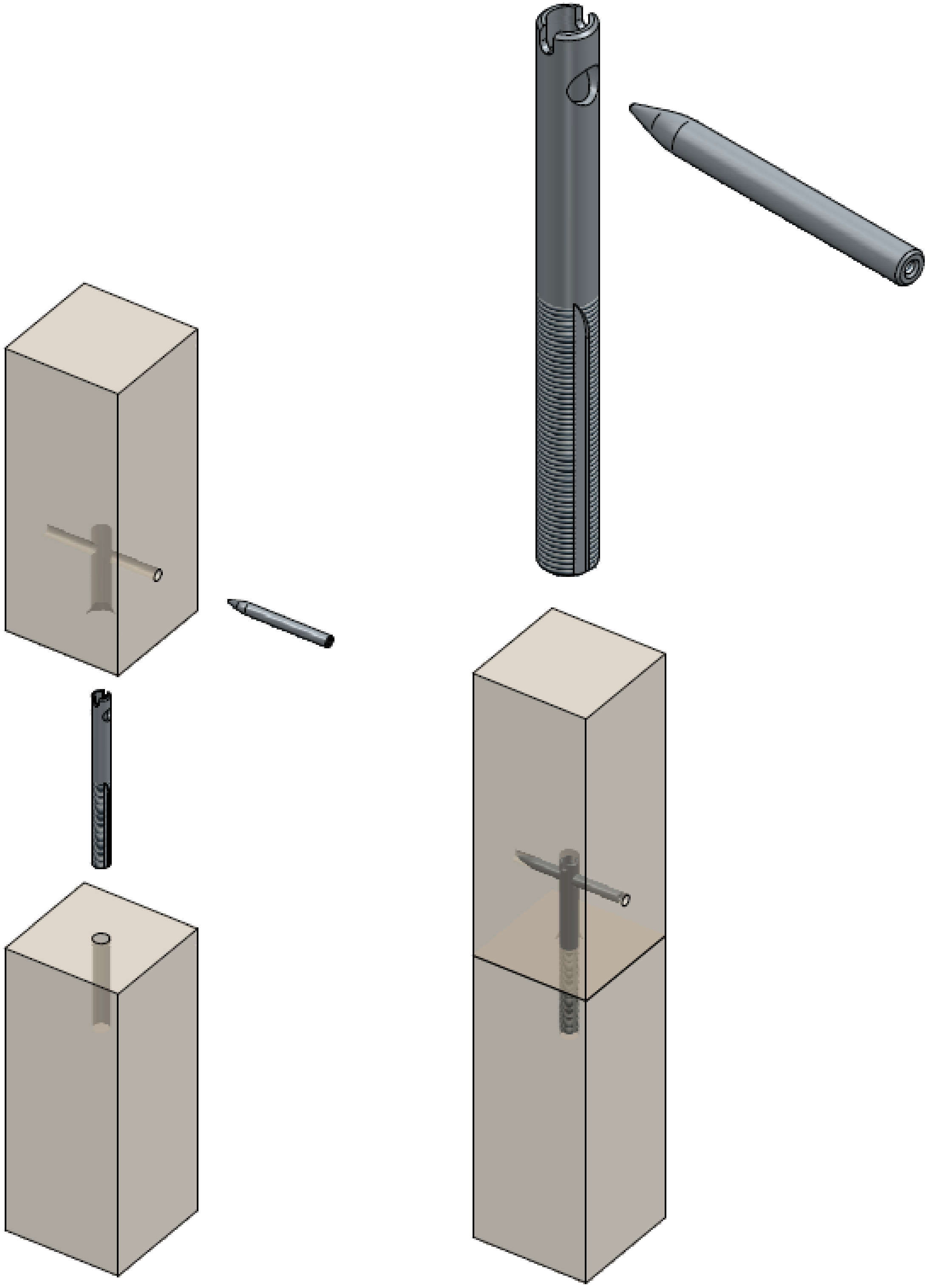


* ... The strength of the component bracing can be adjusted with the insertion depth

Thread pitch 3 mm

KNAPP® WALCO® PIPE C250 and A300

WALCO PIPE C250 and A300 explosion installation drawing in 2 wooden components with inserted clamping bolts D18x180 mm.



Annex B
Characteristic values of load-carrying- capacity and stiffness

B.1 Characteristic capacities of timber-to-timber connector joints.

The downward and the upward directed forces F_1 are assumed to act in the axis of the bolt or pipe. The force F_{23} or F_{45} is assumed to act in the shear plane.

Force F_1 for Knapp WALCO Bolt:

$$F_{1,Bolt,Rk} = n_{screw}^{0,9} \cdot k_{ax,screw} \cdot 0{,}52 \cdot 10^{0,5} \cdot \ell_{ef,screw}^{0,9} \cdot \rho_k^{0,8} \quad \text{for Bolt A130} \qquad (B.1.1)$$

$$F_{1,Bolt,Rk} = \min\begin{cases} n_{screw}^{0,9} \cdot k_{ax,screw} \cdot 0{,}52 \cdot 10^{0,5} \cdot \ell_{ef,screw}^{0,9} \cdot \rho_k^{0,8} \\ 2 \cdot \min\begin{cases} f_{h,bolt10,k} \cdot t_{10} \cdot 10 \\ f_{h,bolt10,k} \cdot t_{10} \cdot 10 \cdot \left[\sqrt{2 + \frac{4 \cdot 60.900}{f_{h,bolt10,k} \cdot 10 \cdot t_{10}^2}} - 1\right] \\ 2{,}3 \cdot \sqrt{60.900 \cdot f_{h,bolt10,k} \cdot 10} \end{cases} \end{cases} \quad \text{for Bolt B130} \qquad (B.1.2)$$

$$F_{1,Bolt,Rk} = \min\begin{cases} k_{ax,ins} \cdot f_{ax,ins,k} \cdot D \cdot \ell_{ef,ins} \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \\ 2 \cdot \min\begin{cases} f_{h,bolt10,k} \cdot t_{10} \cdot 10 \\ f_{h,bolt10,k} \cdot t_{10} \cdot 10 \cdot \left[\sqrt{2 + \frac{4 \cdot 60.900}{f_{h,bolt10,k} \cdot 10 \cdot t_{10}^2}} - 1\right] \\ 2{,}3 \cdot \sqrt{60.900 \cdot f_{h,bolt10,k} \cdot 10} \end{cases} \end{cases} \quad \text{for Bolt C130} \qquad (B.1.3)$$

$$F_{1,Bolt,Rk} = \min\begin{cases} k_{ax,ins} \cdot f_{ax,ins,k} \cdot D \cdot \ell_{ef,ins} \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \\ 2 \cdot \min\begin{cases} f_{h,bolt10,k} \cdot t_{10} \cdot 10 \\ f_{h,bolt10,k} \cdot t_{10} \cdot 10 \cdot \left[\sqrt{2 + \frac{4 \cdot 60.900}{f_{h,bolt10,k} \cdot 10 \cdot t_{10}^2}} - 1\right] \\ 2{,}3 \cdot \sqrt{60.900 \cdot f_{h,bolt10,k} \cdot 10} \end{cases} \end{cases} \quad \text{for Bolt D130} \qquad (B.1.4)$$

Force F_1 for Knapp WALCO Pipe:

$$F_{1,Pipe,Rk} = \min\begin{cases} k_{ax,screw} \cdot f_{ax,pipe,k} \cdot 28 \cdot \ell_{ef,pipe} \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \\ 2 \cdot \min\begin{cases} f_{h,bolt18,k} \cdot t_{18} \cdot 17{,}5 \\ f_{h,bolt18,k} \cdot t_{18} \cdot 17{,}5 \cdot \left[\sqrt{2 + \frac{4 \cdot 235.400}{f_{h,bolt18,k} \cdot 17{,}5 \cdot t_{18}^2}} - 1\right] \\ 2{,}3 \cdot \sqrt{235.400 \cdot f_{h,bolt18,k} \cdot 17{,}5} \end{cases} \end{cases} \qquad (B.1.5)$$

Force F23 for Knapp WALCO Bolt:
Direction of Force F23 is parallel to the plane of member.

$$F_{23,A130,Rk} = \min\left\{\begin{array}{l} 4 \cdot F_{v,up,Rk} \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{4 \cdot F_{v,low,Rk}}\right)^2 + \left(\dfrac{1}{5,5 \cdot F_{ax,low,Rk}}\right)^2}} \end{array}\right\} \tag{B.1.6}$$

$$F_{23,B130,Rk} = \min\left\{\begin{array}{l} \min\left\{\begin{array}{l} 1960 \cdot f_{h,bolt\,20,k} \\ f_{h,bolt\,20,k} \cdot \left[40 \cdot \left(\sqrt{6.001 + \dfrac{6.250}{f_{h,bolt\,20,k}}} - 11\right) - 1.960\right] + \dfrac{F_{1,B130,Rk}}{4} \\ f_{h,bolt\,20,k} \cdot 20 \cdot \left(\sqrt{121 + \dfrac{25.000}{f_{h,bolt\,20,k}}} - 11\right) + \dfrac{F_{1,B130,Rk}}{4} \end{array}\right. \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{4 \cdot F_{v,low,Rk}}\right)^2 + \left(\dfrac{1}{10,9 \cdot F_{ax,low,Rk}}\right)^2}} \end{array}\right\} \tag{B.1.7}$$

$$F_{23,C130,Rk} = \min\left\{\begin{array}{l} 1960 \cdot f_{h,bolt20,k} \\ f_{h,ins,k}\, t_2 D \\ \dfrac{1960 \cdot f_{h,bolt20,k}}{1+\beta}\left[\sqrt{\beta + 2\beta^2\left[1 + \dfrac{t_2}{t_1} + \left(\dfrac{t_2}{t_1}\right)^2\right] + \beta^3\left(\dfrac{t_2}{t_1}\right)^2} - \beta\left(1 + \dfrac{t_2}{t_1}\right)\right] + \dfrac{F_{1,C130,Rk}}{4} \\ \dfrac{2058 \cdot f_{h,bolt20,k}}{2+\beta}\left[\sqrt{2\beta(1+\beta) + \dfrac{4\beta(2+\beta)M_{y,ins,Rk}}{20 \cdot f_{h,bolt20,k}\, t_1^2}} - \beta\right] + \dfrac{F_{1,C130,Rk}}{4} \\ \dfrac{21 \cdot f_{h,bolt20,k}\, t_2}{1+2\beta}\left[\sqrt{2\beta^2(1+\beta) + \dfrac{4\beta(1+2\beta)M_{y,bolt,Rk}}{20 \cdot f_{h,bolt20,k}\, t_2^2}} - \beta\right] + \dfrac{F_{1,C130,Rk}}{4} \\ 1,15\sqrt{\dfrac{2\beta}{1+\beta}}\sqrt{(M_{y,ins,Rk} + M_{y,bolt,Rk}) f_{h,bolt20,k} \cdot 20} + \dfrac{F_{1,C130,Rk}}{4} \end{array}\right. \tag{B.1.8}$$

$$F_{23,D130,Rk} = \min\left\{\begin{array}{l} 2000 \cdot f_{h,bolt20,k} \\ 2000 \cdot f_{h,ins,k} \\ \dfrac{2000 \cdot f_{h,bolt20,k}}{1+\beta}\left[\sqrt{\beta + 6\beta^2 + \beta^3} - 2\beta\right] + \dfrac{F_{1,D130,Rk}}{4} \\ \dfrac{2100 \cdot f_{h,bolt20,k}}{2+\beta}\left[\sqrt{2\beta(1+\beta) + \dfrac{\beta(2+\beta) \cdot 3,16}{f_{h,bolt20,k}}} - \beta\right] + \dfrac{F_{1,D130,Rk}}{4} \\ \dfrac{2100 \cdot f_{h,bolt20,k}}{1+2\beta}\left[\sqrt{2\beta^2(1+\beta) + \dfrac{\beta(1+2\beta) \cdot 2,5}{f_{h,bolt20,k}}} - \beta\right] + \dfrac{F_{1,D130,Rk}}{4} \\ 1,15\sqrt{\dfrac{2\beta}{1+\beta}}\sqrt{5.660.000 \cdot f_{h,bolt20,k}} + \dfrac{F_{1,D130,Rk}}{4} \end{array}\right. \tag{B.1.9}$$

Force F_{23} for Knapp WALCO Pipe:
Direction of Force F_{23} is parallel to the plane of CLT member.

$$F_{23,Rk} = \min \begin{cases} f_{h,1,pipe,k} t_1 \cdot 28 \\ f_{h,2,pipe,k} t_2 \cdot 28 \\ \frac{f_{h,1,pipe,k} t_1 \cdot 28}{1+\beta}\left[\sqrt{\beta + 2\beta^2\left[1+\frac{t_2}{t_1}+\left(\frac{t_2}{t_1}\right)^2\right]+\beta^3\left(\frac{t_2}{t_1}\right)^2} - \beta\left(1+\frac{t_2}{t_1}\right)\right] + \frac{F_{1,pipe,Rk}}{4} \\ 1{,}05\frac{f_{h,1,pipe,k} t_1 \cdot 28}{2+\beta}\left[\sqrt{2\beta(1+\beta)+\frac{4\beta(2+\beta)M_{y,pipe,Rk}}{f_{h,1,pipe,k}\cdot 28 \cdot t_1^2}} - \beta\right] + \frac{F_{1,pipe,Rk}}{4} \\ 1{,}05\frac{f_{h,1,pipe,k} t_2 \cdot 28}{1+2\beta}\left[\sqrt{2\beta^2(1+\beta)+\frac{4\beta(1+2\beta)M_{y,pipe,Rk}}{f_{h,1,pipe,k}\cdot 28 \cdot t_2^2}} - \beta\right] + \frac{F_{1,pipe,Rk}}{4} \\ 1{,}15\sqrt{\frac{2\beta}{1+\beta}}\sqrt{2M_{y,pipe,Rk} f_{h,1,k} \cdot 28} + \frac{F_{1,pipe,Rk}}{4} \end{cases} \quad \text{(B.1.10)}$$

Force F_{45} for Knapp WALCO Bolt:
Direction of Force F_{45} is perpendicular to the plane of the member.

$$F_{45,A130,Rk} = \min \begin{Bmatrix} F_{23,A130,Rk} \\ F_{90,Rk} \end{Bmatrix} \quad \text{(B.1.11)}$$

$$F_{45,B130,Rk} = \min \begin{Bmatrix} F_{23,B130,Rk} \\ F_{90,Rk} \end{Bmatrix} \quad \text{(B.1.12)}$$

$$F_{45,C130,Rk} = \min \begin{Bmatrix} F_{23,C130,Rk} \\ F_{90,Rk} \end{Bmatrix} \quad \text{(B.1.13)}$$

$$F_{45,D130,Rk} = \min \begin{Bmatrix} F_{23,D130,Rk} \\ F_{90,Rk} \end{Bmatrix} \quad \text{(B.1.14)}$$

Force F_{45} for Knapp WALCO Pipe:
Direction of Force F_{45} is perpendicular to the plane of a CLT member or perpendicular to the grain for timber members with WALCO Pipe connectors arranged parallel to grain.

$$F_{45,Rk} = \min \begin{cases} F_{23,Rk} \\ \frac{k_v \cdot f_{v,k} \cdot b \cdot h_{ef}}{1{,}5} \end{cases} \quad \text{(B.1.15)}$$

Where:

n_{screw} Number of WALCO V PH screws per WALCO Bolt plate,

$k_{ax,screw}$ $= k_{ax,rod} = 1$ for $45° \leq \alpha \leq 90°$

$k_{ax,screw}$ $= k_{ax,rod} = 0{,}3 + 0{,}7 \cdot \alpha / 45°$ for $0° \leq \alpha \leq 45°$

If the penetration length of the screw in the timber member is at least 100 mm, and the connection is in service class 1 or 2 within a closed building envelope, $k_{ax,screw}$ may be assumed as follows for $\alpha \leq 45°$:

$$k_{ax,screw} = 0,6 + \frac{0,4 \cdot \alpha}{45°} \qquad \text{for } 0° \leq \alpha \leq 45°$$

$F_{v,up,Rk}$	Characteristic lateral load-carrying capacity of a WALCO V PH screw in the upper timber member
$F_{v,low,Rk}$	Characteristic lateral load-carrying capacity of a WALCO V PH screw in the lower timber member
$F_{ax,low,Rk}$	Characteristic axial load-carrying capacity of a WALCO V PH screw in the lower timber member, $F_{ax,low,Rk} = k_{ax,screw} \cdot 0,52 \cdot 10^{0,5} \cdot \ell_{ef,screw}^{0,9} \cdot \rho_k^{0,8}$
$\ell_{ef,screw}$	Point side penetration length of the threaded WALCO V PH screw in mm,
ρ_k	Characteristic timber density in kg/m³,
$f_{h,bolt10,k}$	Characteristic embedding strength for M12 Bolt,

For bolts arranged parallel to grain:

$f_{h,bolt10,k}$	$= 0,03 \cdot \rho_k$ in Mpa for timber members,	
t_{10}	Penetration depth of M12 bolt in mm	
$f_{h,ins,k}$	Characteristic embedding strength for insert,	
$M_{y,ins,Rk}$	Characteristic yield moment of insert	
$M_{y,bolt,Rk}$	= 125.000 Nmm	
t_1/t_2	The smaller value of timber member thickness and penetration depth in mm,	
β	$(f_{h,2,k} \cdot D)/(f_{h,1,k} \cdot d) = (f_{h,low,k} \cdot D)/(f_{h,up,k} \cdot d)$	
$k_{ax,ins}$	= 1	for $45° \leq \alpha \leq 90°$
$k_{ax,ins}$	$= 0,3 + 0,7 \cdot \alpha / 45°$	for $0° \leq \alpha \leq 45°$

If the penetration length of the insert or threaded rod in the timber member is at least 100 mm, and the connection is in service class 1 or 2 within a closed building envelope, $k_{ax,ins}$ may be assumed as follows for $\alpha \leq 45°$:

$$k_{ax,ins} = 0,6 + \frac{0,4 \cdot \alpha}{45°} \qquad \text{for } 0° \leq \alpha \leq 45°$$

$f_{ax,ins,k}$	= 9 Mpa for inserts or threaded rods,
D	Outer thread diameter of insert or threaded rod,
$\ell_{ef,ins}$	Penetration length of insert or threaded rod,
$f_{ax,pipe,k}$	= 5 Mpa,
$\ell_{ef,pipe}$	Threaded penetration length of pipe connector,
$f_{h,bolt18,k}$	Characteristic embedding strength for M18 Bolt,
$f_{h,bolt20,k}$	Characteristic embedding strength for M20 Bolt,

For bolts arranged parallel to grain:

$f_{h,bolt18,k}$	$= 0,027 \cdot \rho_k$ in Mpa for timber members,
t_{18}	Penetration depth of M20 bolt in mm,
$f_{h,1,pipe,k}$	Characteristic value of timber member 1 pipe embedment strength in MPa,
$f_{h,2,pipe,k}$	Characteristic value of timber member 2 pipe embedment strength in MPa,

For pipes arranged parallel to grain:

$f_{h,pipe,k}$	$= 0,024 \cdot \rho_k$ in Mpa for timber members,
β	$f_{h,2,pipe,k}/f_{h,1,pipe,k}$,
t_1/t_2	The smaller value of timber member thickness and penetration depth in mm,
$M_{y,pipe,Rk}$	Characteristic pipe's yield moment, $M_{y,pipe,Rk}$ = 486.000 Nmm,
$F_{90,Rk}$	Load-carrying capacity according to equation (8.4) in EN 1995-1-1

$$k_v = \min \begin{cases} 1 \\ k_n \cdot \left[\sqrt{h} \left(\sqrt{\alpha(1-\alpha)} + 0{,}8 \frac{x}{h} \sqrt{\frac{1}{\alpha} - \alpha^2} \right) \right]^{-1} \end{cases}$$

$f_{v,k}$ Characteristic shear strength, $f_{v,k}$ = 2,0 N/mm² for solid timber or CLT,

b Beam width in mm, $b \leq 2 \cdot h$,

h Beam depth or CLT wall thickness in mm,

h_{ef} Loaded edge distance of WALCO Pipe in mm,

x Distance from line of action of the support reaction to the corner of the notch, $x = t_1/3$ or $x = t_2/3$

$$\alpha = \frac{h_{ef}}{h}$$

$$k_n = \begin{cases} 4{,}5 & \text{for LVL} \\ 5 & \text{for solid timber} \\ 6{,}5 & \text{for glued laminated timber and CLT} \end{cases}$$

Combined forces

In case of combined forces, the following inequality shall be fulfilled:

$$\left(\frac{F_{1,Ed}}{F_{1,Rd}}\right)^2 + \left(\frac{F_{23,Ed}}{F_{23,Rd}}\right)^2 + \left(\frac{F_{45,Ed}}{F_{45,Rd}}\right)^2 \leq 1 \qquad \text{(B.1.7)}$$

B.2 Connection stiffness

The following slip moduli K_{ser} are to be used for Knapp WALCO Bolt or Pipe connections:

Load direction F1

Knapp WALCO Bolt A130: K_{ser} = 7,0 kN/mm (B.2.1)

Knapp WALCO Bolt B130, C130 or D130 K_{ser} = 15,0 kN/mm (B.2.2)

Knapp WALCO Pipe: K_{ser} = 12,0 kN/mm (B.2.3)

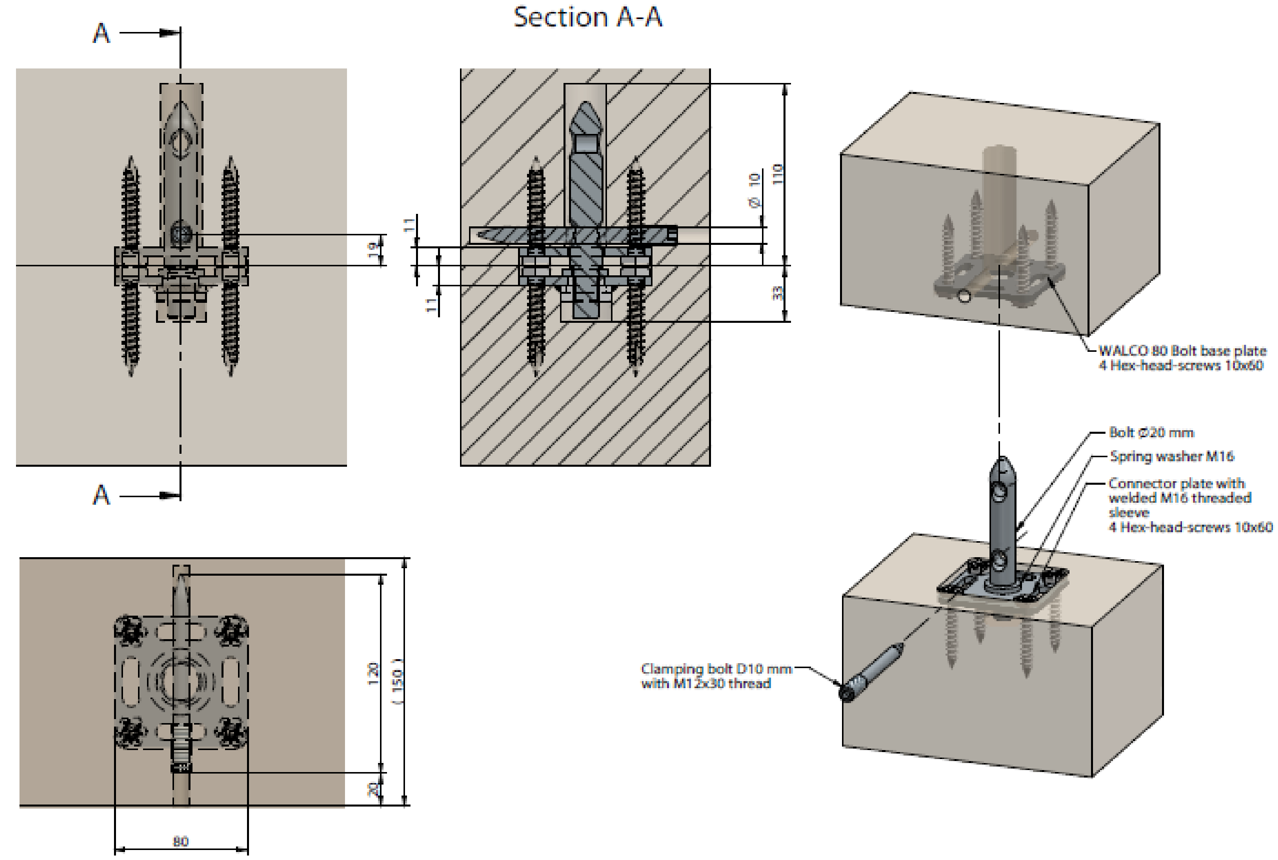
Load directions F_{23} or F_{45}

Knapp WALCO Pipe arranged perpendicular to grain in both timber members:
K_{ser} = 4,0 kN/mm (B.2.4)

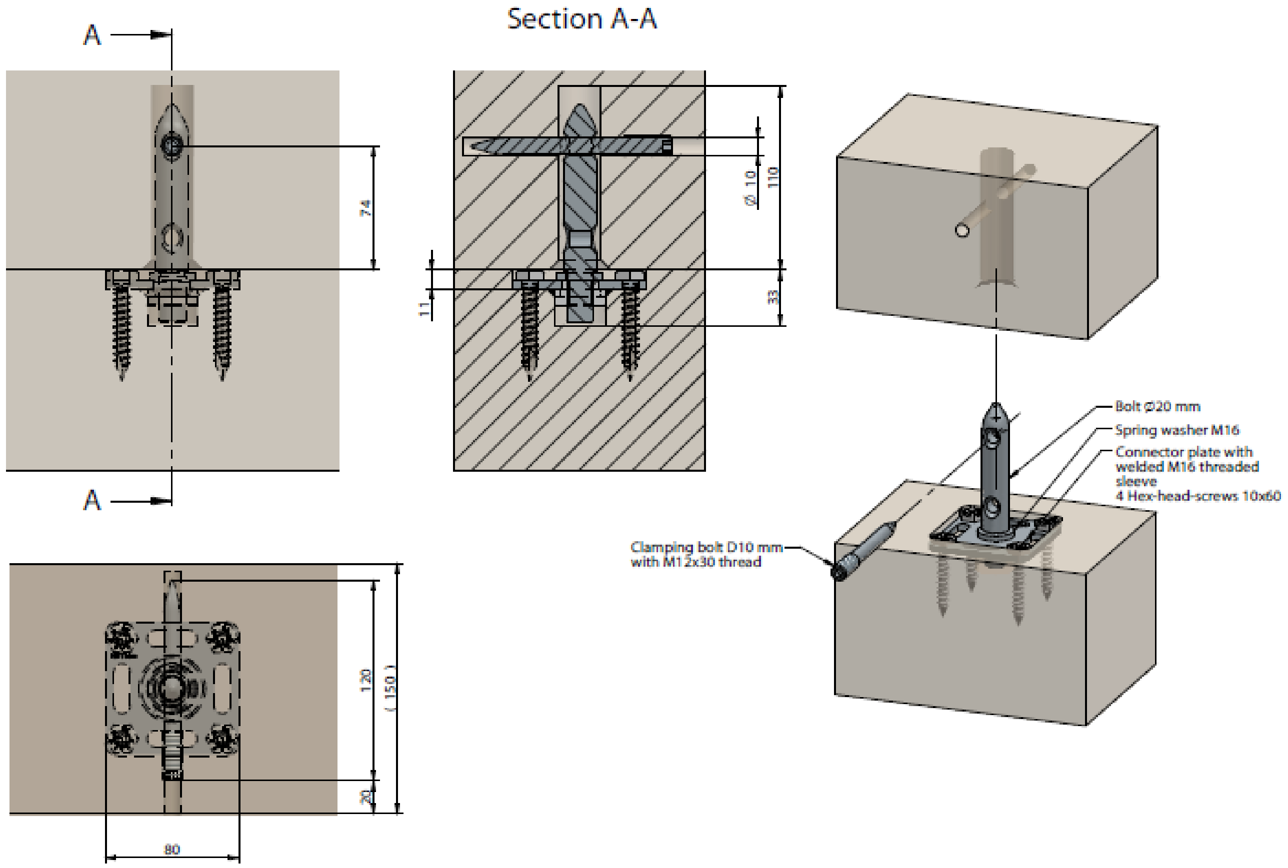
Knapp WALCO Pipe arranged parallel to grain in at least one timber member:
K_{ser} = 1,5 kN/mm (B.2.5)

Annex C
Installation of connectors
WALCO Bolt

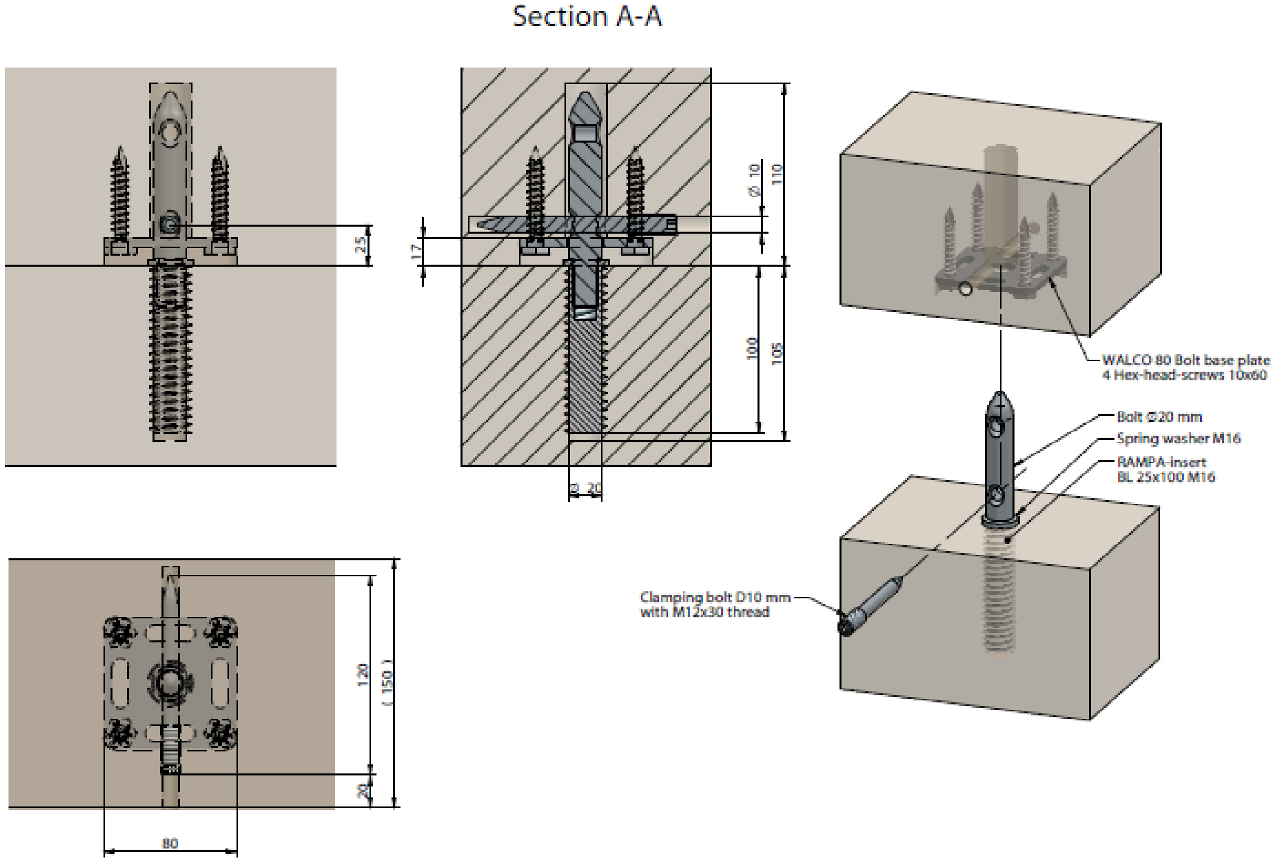
WALCO® Bolt A130 installation instructions



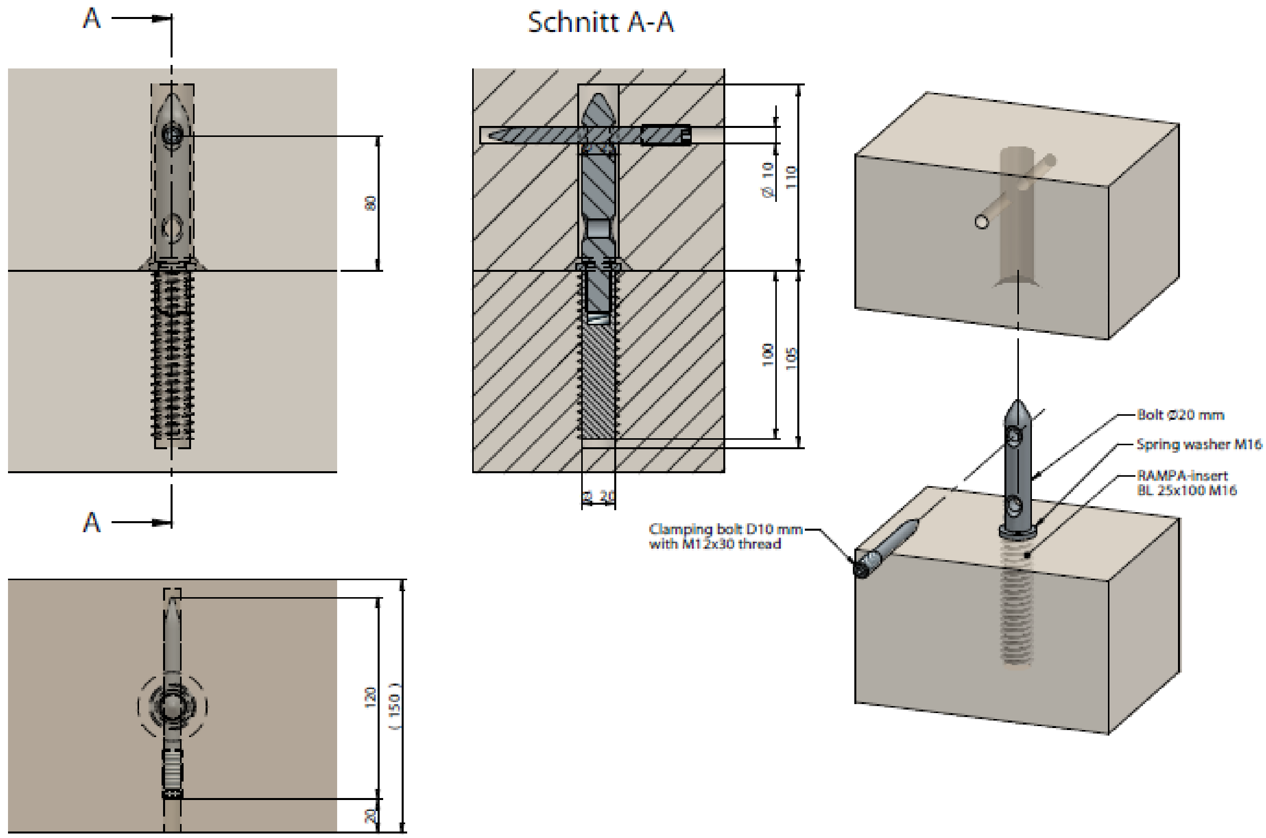
WALCO® Bolt B130 installation instructions



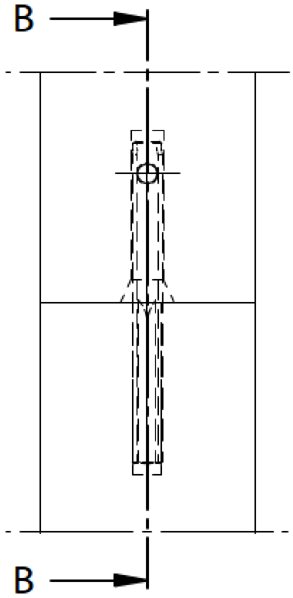
WALCO® Bolt C130 installation instructions



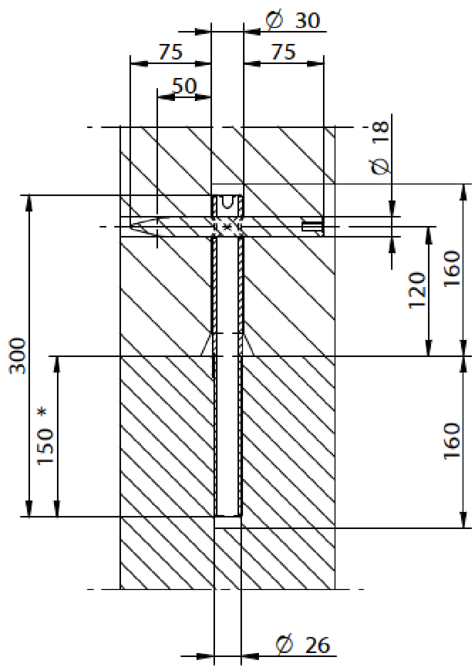
WALCO® Bolt C130 installation instructions

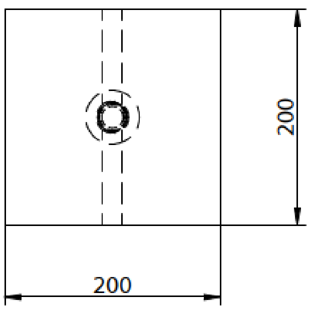


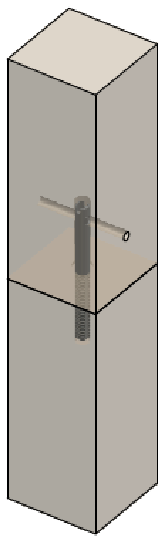
WALCO Pipe



Schnitt B-B







* ... Mit der Eindrehtiefe kann die Festigkeit der Bauteilverspannung abgestimmt werden

Gewindesteigung 3 mm

WALCO PIPE Assembly