# Direct assembly into metals using thread forming screws

according to DIN 7500

### What should be considered in the design and construction processes?

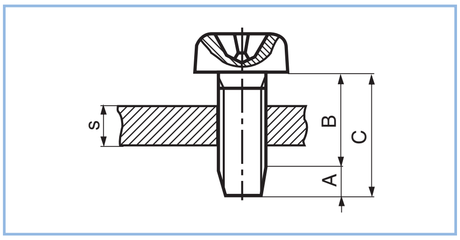
- Thread forming screws to DIN 7500 (trilobular cross-section) produce a chip-free, gaugecorrect metric internal thread.
- The screws are heat-treated to give a tensile strength in use of ca. 800 N/mm².
- It is possible to form threads in ductile metals such as steel, non-ferrous metals and light metals up to ca. 140 to 160 HV.
- Thread forming is not suitable for brittle metals such as grey cast iron.
- Thread forming screws made from A2 stainless steel can only safely be screwed into light metals.
- No other safety features (such as retaining rings) are necessary. Resistance to vibration is provided by the thread friction.
- They can be re-used 10 to 20 times.
- For thin sheets, the use of punch holes can help improve the mechanical properties of the fastening.
- It is recommended that preliminary trials be made for «laser-bored» holes (the cut surfaces may be to hard).
- Preliminary trials should be made for critical applications. Get in touch with Bossard Engineering as early as possible in the development stage of your product.
- For the functional fulfillment of a thread-forming screw a suitable lubrication should be applied. Lubrication systems integrated into the surface protection and / or an additional lubricant can be used.
- There is a risk of failure due to hydrogen embrittlement for thread-forming screws with galvanic coatings. A treatment must be carried out according to ISO 4042 to reduce the risk of hydrogen embrittlement. Highstrength screws with property classes 8.8 and higher must not be replaced by case-hardened thread-forming screws without an adequate examination.

**Note**

Functionally appropriate design of components and selection of the correct type of fastening element are essential requirements for a secure screw connection.
Mechanical and functional properties of self-tapping bolts according to DIN 7500 and ISO 7085.

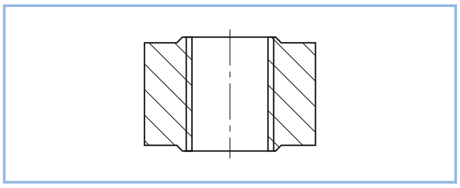
A = conical screw end of max. 4 P
B = usable thread length
C = overall length, tolerance js 16
s = material thickness

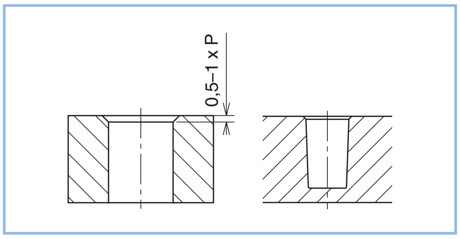
The length of the conical end of the screw, which is not fully load-bearing, should be allowed for when deciding on the screw length.




### Forming the pilot holes

The displacement of the material which occurs when tapping the thread creates a small bulge at the edges of the tapping hole. This can create a problem when screwing smooth parts together. It is therefore recommended that you 90° countersink the edges of the tapping hole to a depth of 0,5 to 1x the thread pitch P or that you make a cylindrical countersunk hole.



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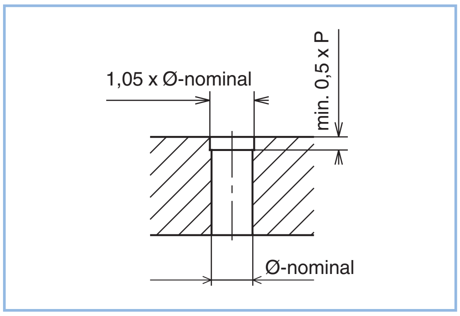
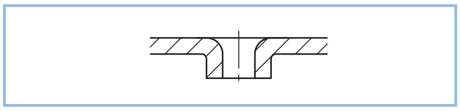
# Construction recommendations

The thread engagement of the individual clamp members can be kept at constant length by putting an appropriate relief bore at the beginning of the pilot hole. Thus, enabling the same driving torque in all clamp members provided, the screw diameter and material are the same.

In thin plates a through hole increases the load-bearing capacity of the fastening.



**Reference**
Ask Bossard Engineering for more detailed information.

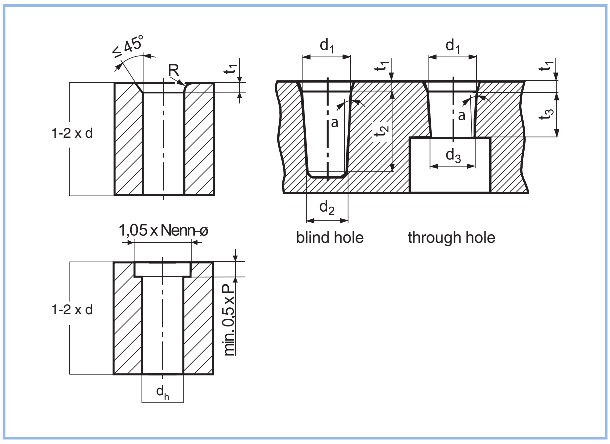
## Strength characteristics, geometry of tapping holes in steel

| Technical details | | Nominal thread diameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | M2 | M2,5 | M3 | M3,5 | M4 | M5 | M6 | M8 |
| **Thread pitch P** | **[mm]** | **0,4** | **0,45** | **0,5** | **0,6** | **0,7** | **0,8** | **1** | **1,25** |
| **max. tightening torque** | **[Nm]** | **Approximately 80 % of minimum breaking torque** | | | | | | | |
| **min. breaking torque[1)]** | **[Nm]** | **0,4** | **1** | **1,8** | **2,8** | **4,1** | **8,7** | **15** | **37** |
| **min. tensile force[1)]** | **[kN]** | **1,65** | **2,7** | **4** | **5,4** | **7** | **11,4** | **16** | **29** |
| **Material thickness s** | **[mm]** | **Diameter of tapping hole d – H11 for steel, HB max. 135; bored or punched** | | | | | | | |
| 2 and smaller | | 1,8 | 2,25 | 2,7 | 3,2 | 3,6 | 4,5 | 5,4 | – |
| 4 | | 1,85 | 2,3 | 2,75 | 3,2 | 3,65 | 4,55 | 5,5 | 7,3 |
| 6 | | – | 2,35 | 2,75 | 3,2 | 3,7 | 4,6 | 5,5 | 7,4 |
| 8 | | – | – | – | – | 3,7 | 4,65 | 5,55 | 7,4 |
| 10 and greater | | – | – | – | – | – | 4,65 | 5,6 | 7,5 |

1) **Torsional test for bolts and screws according to ISO 898, part 7:**
Breaking torque of a screw is determined by clamping it into a test device according the ISO 898, part 7.
The screw shall be exclusively subjected to torsion whereby the minimum breaking torque according to ISO 898, part 7 shall be reached.

## Tapping holes for die-cast metal

All the recommendations must be tested by means of trial assemblies which closely resemble conditions in practice.




## General

$t_1$ [mm]: fillets which provide an advantage for die-cast metals strengthening of the mandrel, centering of the screw, prevention of buckling of the material and adaptation to suit cost-effective standard screw lengths

$t_2$ [mm]: bearing part of the tapping hole, taper angle α max. 1°

$t_3$ [mm]: thread engagement length for the tapping hole, taper angle α max. 1°

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# Construction recommendations

## Reference values for hole geometry into aluminum and zinc cast

| Dimensions | | Thread | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| mm | | M2 | M2,5 | M3 | M3,5 | M4 | M5 | M6 | M8 |
| $d_h$ H11 | | 1,81 | 2,3 | 2,75 | 3,25 | 3,65 | 4,65 | 5,5 | 7,5 |
| $d_1$ | min | 1,85 | 2,33 | 2,84 | 3,31 | 3,74 | 4,72 | 5,66 | 7,61 |
| | max. | 1,91 | 2,39 | 2,90 | 3,39 | 3,82 | 4,80 | 5,74 | 7,69 |
| $d_2$ | min. | 1,75 | 2,22 | 2,70 | 3,13 | 3,56 | 4,50 | 5,40 | 7,27 |
| | max. | 1,81 | 2,28 | 2,76 | 3,21 | 3,64 | 4,58 | 5,48 | 7,35 |
| $d_3$ | min. | 1,80 | 2,28 | 2,75 | 3,22 | 3,65 | 4,61 | 5,5 | 7,44 |
| | max. | 1,86 | 2,34 | 2,83 | 3,30 | 3,73 | 4,69 | 5,61 | 7,52 |
| $t_1$ | | variable, minimum 1 x thread pitch p | | | | | | | |
| $t_2$ | | 4 | 5 | 6 | 7 | 8 | 10 | 12 | 16 |
| $t_3$ | | 2 | 2,5 | 3 | 3,5 | 4 | 5 | 6 | 8 |

### What should you consider during assembly?

- Secure and cost-effective fastenings can only be produced with screwdrivers which have controlled torque and/or turning angle.
- The speed should lie between 300 and 1000 rpm. Both electrically- and pneumaticallypowered screwdrivers can be used.
- The repeatability of the accuracy of the screwing process should be checked in trials using building components, in order to allow for effects which have not yet been detected.
- If you want to assemble components using automatic screwing machines then get in touch with us as early as possible, so that we can define and have your screws manufactured to the required quality for automatic machines (take delivery time into account). The automatic assembly of «standard stock screws» is not normally economically justifiable.

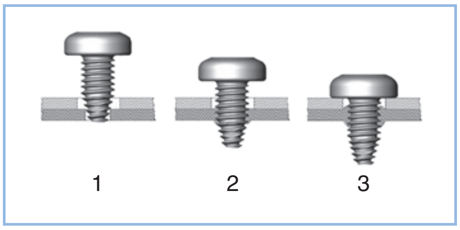
**Reference**
Calculating the torques, **page 85**

## SHEETtracs® – Self-tapping round washer head screws

### Prepunch diameter recommendations 1)

| SHEETtracs® | Major-Ø $d_1$ [mm] | Sheet thickness s [mm] | Prepunch-Ø $d_v$ (Tolerance + 0,1) [mm] | Tightening torque $M_A$ [Nm] |
|---|---|---|---|---|
| 30 | 3 | 0,5–0,63 | 2 | 1 |
| | | 0,63–0,88 | 2,1 | 1,2 |
| 35 | 3,5 | 0,63–0,88 | 2,2 | 1,3 |
| | | 0,88–1 | 2,4 | 1,5 |
| | | 1–1,25 | 2,6 | 1,5 |
| 40 | 4 | 0,63–0,88 | 2,6 | 2 |
| | | 0,88–1 | 2,8 | 2,5 |
| | | 1–1,25 | 3 | 2,5 |
| 50 | 5 | 0,63–0,75 | 3,8 | 2,5 |
| | | 0,75–0,88 | 4,1 | 3 |
| | | 0,88–1 | 4,2 | 3,5 |
| | | 1–1,25 | 4,3 | 3,5 |
| | | 1,25–1,5 | 4,4 | 4 |
| 60 | 6 | 0,88–1 | 4,8 | 4 |
| | | 1–1,25 | 4,9 | 5 |
| | | 1,25–1,5 | 5,1 | 6 |

1) Recommendation for sheet / sheet metal joints out of cold rolled, soft steels according to DIN EN 10130 (DC 01–DC 04)




**Application**
1 Apply
2 Thread forming
3 Tightening

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Construction recommendations

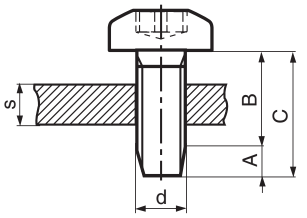
## Direct assembly into stainless steels using thread forming screws
according to DIN 7500

### What should be considered in the design and construction processes?
– Bossard ecosyn®-IMX screws simplify your manufacturing processes, increase the level of connection reliability and have a proven corrosion resistance.

– By using quenched and tempered martensitic stainless steel in screw production, ecosyn®-IMX screws can also be assembled into stainless steels, such as 1.4301 / AISI 304. Thread forming screws to DIN 7500 (trilobular cross-section) produce a chip-free metric internal thread.

### Design of the pilot holes
Please note that the pilot hole diameter depends on the material hardness, material thickness and hole manufacturing methodology. In addition, thread-forming screws have a tapered lead thread. This makes assembly easier as it aligns the screw and begins to form the thread. This not fully load-bearing area A is 4 x P (P = thread pitch).

A = Conical screw end of max. 4 P
B = Usable thread length
C = Overall length
d = Hole diameter (H11)
s = Material thickness




### Reference values for hole geometry into stainless steel
Punching processes can harden the edge layer of the pilot hole. To ensure a process-reliable use, practical assembly tests are required.

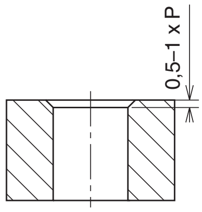
The reference values are based on laboratory tests and should be checked and approved for the respective application. Under special practical conditions additional adjustments may be necessary!

| Material thickness s [mm] | Hole diameter d (H11) M2,5 | M3 | M4 | M5 |
|---|---|---|---|---|
| 1 | 2,25 | – | – | – |
| 2 | 2,3 | 2,75 | – | – |
| 3 | 2,35 | 2,8 | 3,7 | 4,6 |
| 4 | – | 2,85 | 3,75 | 4,65 |
| 5 | – | – | 3,8 | 4,7 |
| 6 | – | – | – | 4,75 |

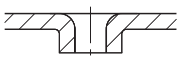
All recommendations are always to be checked via practical assembly tests.

### Selection of hole geometries
– Punching
– Laser cutting
– Drilling (recommended chamfer 0,5 – 1,0 x P)
– Sheet metal through hole according to ~DIN 7952-1
  Increase the thread engagement for thin sheets.
  No countersinking necessary.

A missing countersink can pull material into the clamped part creating uneven surfaces and gaps.




45° countersinking recommended for drilling holes



Punched through hole



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# Construction recommendations

**Note**

Functionally appropriate design of components and selection of the correct type of fastening element are essential requirements for a secure screw connection. Screws ecosyn®-IMX made of a martensitic, quenched and tempered stainless steel are especially intended for direct assembly in corrosion resistant thin sheet metal (stainless steel A2, etc.). The screws can be assembled into all plastically, deformable materials with a maximum hardness range from 135 HV to 250 HV. Stress corrosion cracking is possible in aggressive environments and with certain material combinations.

## Reference values for assembly

### Torsional strength

The forming torque must always be less than the minimum breaking torque

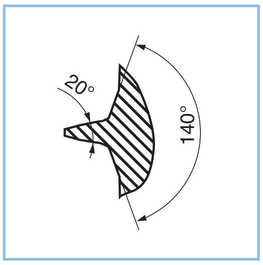
For the assembly, we recommend a driving tool with a process-reliable shutdown function. The recommended assembly speed is 400 rpm. The tightening torque is determined in practical applications.

| Nominal diameter | Minimum breaking torque [Nm] |
|---|---|
| M2,5 | 1,2 |
| M3 | 2,1 |
| M4 | 4,5 |
| M5 | 9,4 |

## Direct assembly in thermoplastics using Delta PT® screws

The Delta PT® has all the well-known properties of the PT® screw. In addition the Delta PT® screw offers all the following advantages:

- Thread angle geometry of 20° favours working of the plastic
- Up to 50 % more tensile and torsional strength for the same nominal Ø $d_1$, thanks to the increased crosssection of the core
- Increased stability against vibration thanks to the smaller thread pitch
- Increased cycle stress stability
- Smaller Ø tolerances
- Robust fastener, which can transfer more preload
- The DELTA PT® prognosis programme DELTACALC® allows a design based on preload oriented engineering (~VDI 2230).




### Cost-effective connections

The following example shows that, for the same depth of thread engagement $A_{FL}$, thanks to the smaller thread pitch P it is possible to design for a smaller length of thread engagement te. The required screw depth for the Delta PT® screw can be calculated from the given depth of thread engagement $A_{FL}$.

A comparison of the Delta PT® with the PT® screw shows that:
**Use of the DELTA PT® allows you to use a shorter and more cost-effective screw.**

| | $A_{FL}$ [mm²] | P [mm] | d [mm] | $t_e$ [mm] |
|---|---|---|---|---|
| PT® K 50 | 35 | 2,24 | 4 | 13,24 |
| Delta PT® 50 | 35 | 1,8 | 4 | 10,42 |
| Delta PT® 40 | 35 | 1,46 | 3,2 | 11,75 |

$$A_{FL} = (d_1^2 - d^2) \cdot \frac{\pi}{4} \cdot \frac{t_e}{P}$$

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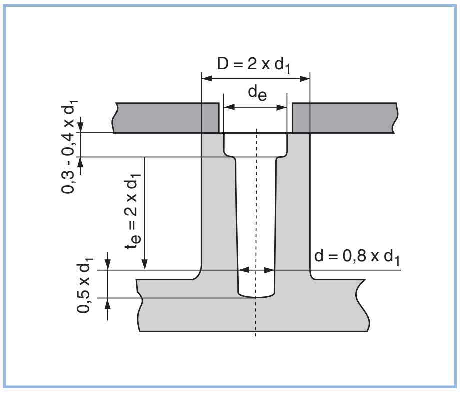
# Construction recommendations

## Construction recommendations

- For simple fastenings the recommendations published here are quite adequate
- We would be pleased to help you with the design of fastenings under operational loadings, and can also provide support through the use of DELTACALC®
- Select larger head diameters (BN 20040) for fastening together parts made of plastic. The head friction increases the safety of the process during assembly, a smaller surface pressure results in less relaxation and so in greater residual locking forces.
- Avoid using countersunk screws for clamping parts made from plastic. The 90° angle results in radial as well as axial relaxation, and where the edge distance is small this can lead to large losses in preload, and so to a break in the part being clamped.
- Avoid using elongated holes in clamping parts made from plastic. Lack of bearing surface can lead to the forming torque being greater than the head friction torque and this can make it impossible to construct a mounting process secured.
- Transverse forces should be taken up by the engagement between the components.
- Provide a pressure relief hole de (avoids stress cracks)

## Shape of the hole for Delta PT® screws

The maximum achievable preload when overtightening is the criteria for determining the optimum **hole Ø d**. It is less dependent on the tube material and the length of engaged thread $t_e$, and more dependent on the thread pitch P and the nominal Ø $d_1$ of the screw. The design applies to all conventional plastics with a modulus of elasticity of up to E = 15000 N/mm² (hole-Ø d for special plastics available on request):




D outside Ø
d pilot holed Ø
te length of thread engagement
de edge relief
$d_1$ nominal Ø of the screw thread

**$d = 0{,}8 \cdot d_1$**
**$d_e = d_1 + 0{,}2$ mm**

The **pressure relief hole $d_e$** is particularly important, since it gives a favourable distribution of edge stresses and so prevents the tube from shattering, particularly with plastics such as polycarbonates which are subject to stress cracking. It also ensures the even support of the clamping part. Bulging of the plastic when forming the first turn of the thread.

To optimise the fastening the **hole diameter should not exceed Ø $d = 0{,}88 \times d_1$.**

In practice deviations from these recommendations may arise, for the following reasons:
- Processing conditions during manufacture of the plastic
- Design of the injection moulding equipment
- Position of the injection point
- Creation of flow seams
- Local texture, e.g. through use of additives and fillers such as colour pigments and fibres.
- The plastics can be modified in different ways, depending on the manufacturer.

**Note**
We recommend that **control assembly runs** be made using the first available parts.

**Reference**
Ask Bossard Engineering for more detailed information.



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# Construction recommendations

## Added value through calculation performance

The preliminary design of screwed connections in thermoplastic can be simulated using the DELTACALC® calculation program. Based on VDI 2230, it permits a design to be made related to the preload. These possibilities range from dimensioning through load capacity and on to the working life of the connection.

If the **operating forces of the loaded connections** are known, the check lists for possible engineering support may be useful for you.

For inquiries on DELTACALC®-calculations, please contact your Bossard contact person (bossard@bossard.com).

## Tensile fracture load

PT 10 version
(Steel, hardened and tempered, strength analogous to 10.9)

| Nominal size of Delta PT® | Nominal Ø ($d_1$) [mm] | Min. tensile strenght load [kN] |
|---|---|---|
| 20 | 2 | 1,6 |
| 22 | 2,2 | 1,9 |
| 25 | 2,5 | 2,7 |
| 30 | 3 | 3,8 |
| 35 | 3,5 | 5,2 |
| 40 | 4 | 6,8 |
| 45 | 4,5 | 8,6 |
| 50 | 5 | 10 |
| 60 | 6 | 15 |
| 70 | 7 | 21 |
| 80 | 8 | 28 |
| 100 | 10 | 44 |

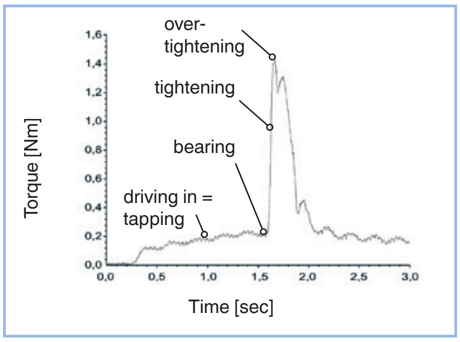
## What should you consider during assembly?

– Secure and cost-effective fastenings can only be produced with screwdrivers which have controlled torque and/or turning angle. The heat needed for low-stress formation of the thread in plastics is created by friction generated when driving in the screw.
– **The rotational speed should be between 300 and 800 rpm.**
– Both electrically- and pneumatically-powered screwdrivers can be used.
– Trials using components should be made to check the calculated values and the repeatability of the screwing process, in order to allow for effects which have not yet been detected.
– If you want to assemble components using automatic screwing machines then get in touch with us as early as possible, so that we can define and have your screws manufactured to the **required quality for automatic machines** (take delivery time into account). The automatic assembly of «standard stock screws» is not normally economically justifiable.

**Reference**
Detail on the Tubus, **page 84**

## Calculating the torque

In order to achieve optimal safety during assembly, the difference between the driving torque (Me) and the stripping torque (Mü) must be as large as possible. The true screwing parameters can be established by Bossard, using original components in their «Applications testing laboratory». The optimum tightening torque MA to be set on the screwdriver for the assembly process is determined based on customer-specific requirements. The results are then documented in the form of a «Technical Report».




## Check list for a pre-design of the self-tapping fastener joint

**Remark**
The results of the Bossard recommendation must be confirmed by practice experiments on the components of mass production.

### Detail on the screw

screw ..........
standard reference ..........
shape of head ..........
head-Ø [mm] ..........
nominal thread-Ø [mm] ..........
length [mm] ..........

### Detail on the clamping part

material specification ..........
brand name ..........
thickness of clamping part [mm] ..........
hole-Ø [mm] ..........

### Detail on the Tubus

material specification ..........
brand name ..........
pilot holed-Ø [mm] ..........
tube outside-Ø [mm] ..........
length of thread engagement [mm] ..........
edge relief-Ø [mm] ..........
hight of edge relief [mm] ..........

### Details on the assembly

required tightening torque [Nm] ..........
preload / clamping load [kN] ..........
working load (axial) [N] ..........
dynamic stress condition [yes / no] ..........
static stress condition [yes / no] ..........
service temperature [°C] ..........
hight of edge relief [mm] ..........
service periode [h] ..........

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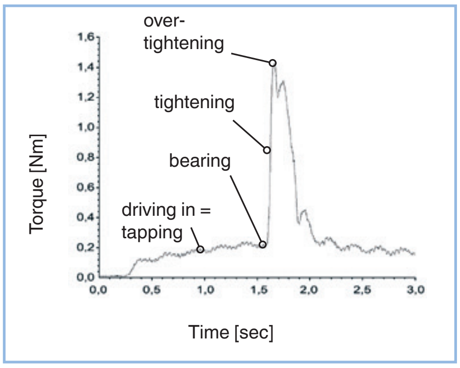
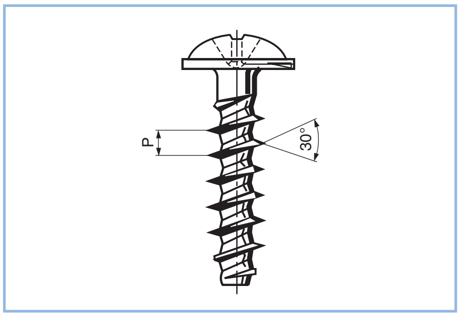
Construction recommendations

## Direct assembly in thermoplastics using PT® screws / ecosyn®-plast




### Advantages of PT® screws / ecosyn®-plast

- Low driving torque, high stripping torque
- High assembly safety
- Excellent vibration resistance
- Low bursting tendency
- No excessive joint relaxation therefore plastic components do not shift
- Cost-effective fastener for direct fastening in thermoplastics




The PT® screw / ecosyn®-plast is capable of making direct assembly into thermoplastic very secure and will establish high-strength joints.

### Design guidelines

- For fastening plastic parts, specify a large head diameter (BN 13578). This increases friction under the head, making a safer joint. Also a larger head reduces the surface pressure which in turn minimizes joint relaxation and ultimately increases the residual clamp load.
- Do not use countersunk screws. The 90° head angle not only results in axial forces but also radial forces, hence causing greater joint relaxation in parts with narrow edge margins. The preload would be unsafe.
- Avoid elongated holes in plastic parts, as they would create a small bearing area, possibly causing the driving torque to be bigger than the underhead friction torque. Such a joint would be unsafe.
- Shear forces should be absorbed by form-fitting components.
- Furnish the pilot hole de entrance with a counterbore (avoids stress cracking).

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# Construction recommendations

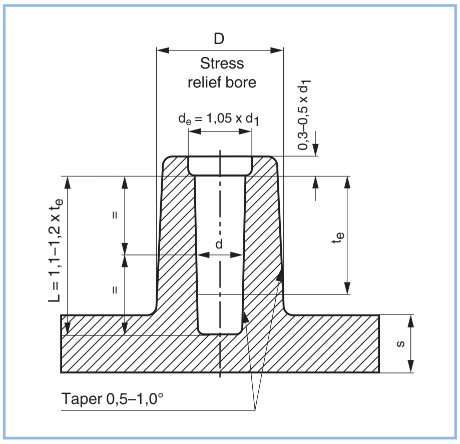
## Pilot hole design for PT® screws / ecosyn®-plast

For an optimal design that will enable the construction to last in real life, it is absolutely necessary to design the pilot hole geometry according to the specific material whish is selected. The details shown here are based on laboratory trials with modelled samples. In practice some changes may be required. We recommend that you make assembly tests using prototypes.

| Material | hole Ø d | external Ø D | length of thread engagement $t_e$ |
|---|---|---|---|
| ABS/PC blend | 0,80 x $d_1$ | 2,00 x $d_1$ | 2,00 x $d_1$ |
| ASA | 0,78 x $d_1$ | 2,00 x $d_1$ | 2,00 x $d_1$ |
| PA 4.6 | 0,73 x $d_1$ | 1,85 x $d_1$ | 1,80 x $d_1$ |
| PA 4.6 - GF 30 | 0,78 x $d_1$ | 1,85 x $d_1$ | 1,80 x $d_1$ |
| PA 6 | 0,75 x $d_1$ | 1,85 x $d_1$ | 1,70 x $d_1$ |
| PA 6 - GF 30 | 0,80 x $d_1$ | 2,00 x $d_1$ | 1,90 x $d_1$ |
| PA 6.6 | 0,75 x $d_1$ | 1,85 x $d_1$ | 1,70 x $d_1$ |
| PA 6.6 - GF 30 | 0,82 x $d_1$ | 2,00 x $d_1$ | 1,80 x $d_1$ |
| PBT | 0,75 x $d_1$ | 1,85 x $d_1$ | 1,70 x $d_1$ |
| PBT - GF 30 | 0,80 x $d_1$ | 1,80 x $d_1$ | 1,70 x $d_1$ |
| PC | 0,85 x $d_1$ | 2,50 x $d_1$ | 2,20 x $d_1$[1)] |
| PC - GF 30 | 0,85 x $d_1$ | 2,20 x $d_1$ | 2,00 x $d_1$[1)] |
| PE (weich) | 0,70 x $d_1$ | 2,00 x $d_1$ | 2,00 x $d_1$ |
| PE (hart) | 0,75 x $d_1$ | 1,80 x $d_1$ | 1,80 x $d_1$ |
| PET | 0,75 x $d_1$ | 1,85 x $d_1$ | 1,70 x $d_1$ |
| PET - GF 30 | 0,80 x $d_1$ | 1,80 x $d_1$ | 1,70 x $d_1$ |
| PMMA | 0,85 x $d_1$ | 2,00 x $d_1$ | 2,00 x $d_1$ |
| POM | 0,75 x $d_1$ | 1,95 x $d_1$ | 2,00 x $d_1$ |
| PP | 0,70 x $d_1$ | 2,00 x $d_1$ | 2,00 x $d_1$ |
| PP - TV 20 | 0,72 x $d_1$ | 2,00 x $d_1$ | 2,00 x $d_1$ |
| PPO | 0,85 x $d_1$ | 2,50 x $d_1$ | 2,20 x $d_1$[1)] |
| PS | 0,80 x $d_1$ | 2,00 x $d_1$ | 2,00 x $d_1$ |
| PVC (hard) | 0,80 x $d_1$ | 2,00 x $d_1$ | 2,00 x $d_1$ |
| SAN | 0,77 x $d_1$ | 2,00 x $d_1$ | 1,90 x $d_1$ |

$d_1$ = nominal thread Ø

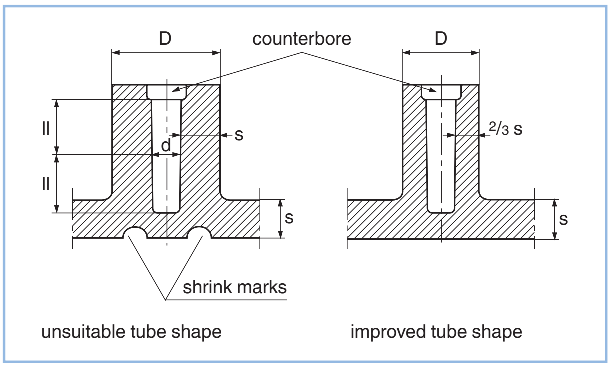
1) Since materials susceptible to stress corrosion cracking are being dealt with here, the tests recommended by the manufacturer should be carried out. The relief bore is particularly important here, since it ensures a favourable distribution of the peripheral stresses.




## Changes of shape

Occur for the given shrink hole shape, shrink marks or extended injection cycles; the form can be changed as follows:
– Reduce external diameter D of the tube
– Increase the diameter d of the hole
– Increase tapping hole depth and so length of screw thread engagement, in order to compensate for the losses in resistance to stripping.

Select tapping holes which are sufficiently deep so that under no circumstances can the assembled screws rest in the base of the hole.




## Tensile strength load PT® screws

Steel, hardened and tempered, strength analogous to 10.9

| Nominal size | Nominal Ø $d_1$ | Min. tensile strength load |
|---|---|---|
| PT® | [mm] | [kN] |
| K18 | 1,8 | 1,1 |
| K20 | 2 | 1,3 |
| K22 | 2,2 | 1,6 |
| K25 | 2,5 | 2 |
| K30 | 3 | 2,7 |
| K35 | 3,5 | 3,6 |
| K40 | 4 | 4,6 |
| K50 | 5 | 7 |
| K60 | 6 | 9,8 |
| K70 | 7 | 13 |
| K80 | 8 | 16 |
| K100 | 10 | 25 |

**Reference**
What should you consider during assembly?, **page 85**

**Reference**
Calculating the torques, **page 85**

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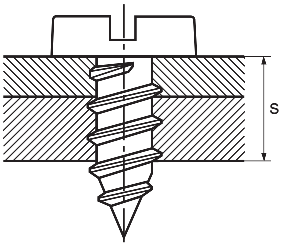
## Sheet metal joints
according to DIN 7975

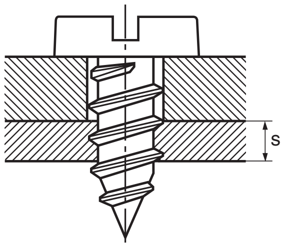
The information below represents general recommendations for the use of screws for sheet metal joints. The different types are shown by example.

Sheet metal screws type C with tip (also known as search tip) are predominantly used. This specially apply to assembly into several sheets, in which hole offsetting is to be expected.

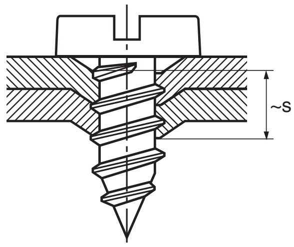
**Minimum total thickness of the (sheet metals s) to be fastened**
The total thickness of the fastened parts shall be bigger than the thread pitch of the applied tapping screw; or else, because of the thread run out underneath the head, a sufficient tightening torque can not be applied. Should this be the case, joints such as shown in figure 3 to 6 should be applied.



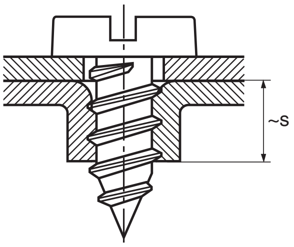

1. Simple fastening (two core holes)



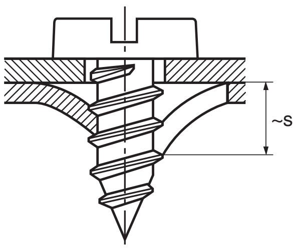

2. Simple fastening with clearance hole



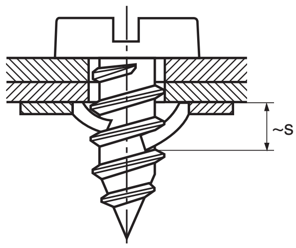

3. Pierced core hole (thin sheet metal)




4. Extruded core hole (thin sheet metal)




5. Pressed hole fastening joint




6. Fastening with spring nut

**Note**
- Sheet metal screws are not intended for transferring high forces. There are no reference values for the pre-loads.
- The pressed hole connection can be used with thin sheet metals, especially at mass productions. The pressed hole is produced by stamping, slicing and forming of the spiral according to the thread pitch.
- The use of «Cage nuts» makes it possible to use sheet metal screws independently of metal thickness or the metal material.
- For assembly into austenitic metals the assembly torques have to be verified by tests.
- Stainless sheet metal screws can only be used in light-alloy metals in order to obtain sufficient security in the assembly process. If used in steel or stainless steel only practical tests can define the assembly parameters.

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## Construction recommendations

### Self-tapping screws / sheet metal thickness / pilot hole diameters

The following reference values are valid only for case hardened steel self-tapping screws as shown in Figure 2 on **page 88.** The tightening torques are max. 50 % of the minimum breaking torque. Prior tests must be carried for the utilisation of other screws or other sheet metal materials. Punched pilot holes must be 0,1 to 0,3 mm larger than normal. The screws must be tightened in the direction the hole was punched.

| Thread diameter | Pitch | Material strength | Diameter of the pilot hole for $d_b$ thread dimensions ST 2,2 to ST 6,3 | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rm | Sheet metal thickness s [mm] | | | | | | | | | | | | | | | | | | | | |
| | P [mm] | [N/mm²] | 0,8 | 0,9 | 1,0 | 1,1 | 1,2 | 1,3 | 1,4 | 1,5 | 1,6 | 1,7 | 1,8 | 1,9 | 2,0 | 2,2 | 2,5 | 2,8 | 3,0 | 3,5 | 4,0 | 4,5 | 5,0 |
| **ST 2,2** | 0,8 | from 100 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | – | – | – | – | – | – | – | – | – | – |
| | | approx. 300 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,8 | 1,8 | 1,8 | 1,8 | – | – | – | – | – | – | – | – | – | – |
| | | up to 500 | 1,7 | 1,7 | 1,8 | 1,8 | 1,8 | 1,8 | 1,9 | 1,9 | 1,9 | 1,9 | 1,9 | – | – | – | – | – | – | – | – | – | – |
| **ST 2,9** | 1,1 | from 100 | – | – | – | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | – | – | – | – | – | – | – |
| | | approx. 300 | – | – | – | 2,2 | 2,2 | 2,2 | 2,2 | 2,2 | 2,3 | 2,3 | 2,3 | 2,4 | 2,4 | 2,4 | – | – | – | – | – | – | – |
| | | up to 500 | – | – | – | 2,2 | 2,2 | 2,3 | 2,4 | 2,4 | 2,4 | 2,4 | 2,5 | 2,5 | 2,5 | 2,5 | – | – | – | – | – | – | – |
| **ST 3,5** | 1,3 | from 100 | – | – | – | – | – | 2,6 | 2,7 | 2,7 | 2,7 | 2,7 | 2,7 | 2,7 | 2,7 | 2,7 | 2,7 | 2,7 | – | – | – | – | – |
| | | bei ca. 300 | – | – | – | – | – | 2,6 | 2,7 | 2,7 | 2,7 | 2,7 | 2,8 | 2,8 | 2,9 | 2,9 | 3,0 | 3,0 | – | – | – | – | – |
| | | up to 500 | – | – | – | – | – | 2,7 | 2,8 | 2,9 | 2,9 | 2,9 | 2,9 | 3,0 | 3,0 | 3,0 | 3,1 | 3,1 | – | – | – | – | – |
| **ST 3,9** | 1,4 | from 100 | – | – | – | – | – | 2,9 | 2,9 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | – | – | – | – |
| | | approx. 300 | – | – | – | – | – | 2,9 | 2,9 | 3,0 | 3,0 | 3,1 | 3,1 | 3,2 | 3,2 | 3,2 | 3,3 | 3,4 | 3,4 | – | – | – | – |
| | | up to 500 | – | – | – | – | – | 3,1 | 3,1 | 3,2 | 3,2 | 3,3 | 3,3 | 3,3 | 3,3 | 3,4 | 3,4 | 3,4 | 3,5 | – | – | – | – |
| **ST 4,2** | 1,4 | from 100 | – | – | – | – | – | – | 3,1 | 3,2 | 3,2 | 3,2 | 3,2 | 3,2 | 3,2 | 3,2 | 3,2 | 3,2 | 3,2 | 3,3 | – | – | – |
| | | bei ca. 300 | – | – | – | – | – | – | 3,1 | 3,2 | 3,2 | 3,2 | 3,3 | 3,3 | 3,4 | 3,4 | 3,5 | 3,6 | 3,6 | 3,6 | – | – | – |
| | | up to 500 | – | – | – | – | – | – | 3,4 | 3,4 | 3,4 | 3,4 | 3,5 | 3,5 | 3,5 | 3,6 | 3,6 | 3,6 | 3,7 | 3,7 | – | – | – |
| **ST 4,8** | 1,6 | from 100 | – | – | – | – | – | – | – | – | 3,6 | 3,6 | 3,6 | 3,6 | 3,6 | 3,6 | 3,6 | 3,6 | 3,7 | 3,8 | 4,0 | – | – |
| | | approx. 300 | – | – | – | – | – | – | – | – | 3,6 | 3,7 | 3,8 | 3,8 | 3,9 | 3,9 | 4,0 | 4,1 | 4,1 | 4,2 | 4,2 | – | – |
| | | up to 500 | – | – | – | – | – | – | – | – | 3,9 | 4,0 | 4,0 | 4,0 | 4,1 | 4,1 | 4,2 | 4,2 | 4,2 | 4,3 | 4,3 | – | – |
| **ST 5,5** | 1,8 | from 100 | – | – | – | – | – | – | – | – | – | – | 4,2 | 4,2 | 4,2 | 4,2 | 4,2 | 4,2 | 4,2 | 4,4 | 4,6 | 4,7 | – |
| | | approx. 300 | – | – | – | – | – | – | – | – | – | – | 4,3 | 4,4 | 4,4 | 4,5 | 4,7 | 4,7 | 4,8 | 4,8 | 4,9 | 4,9 | – |
| | | up to 500 | – | – | – | – | – | – | – | – | – | – | 4,6 | 4,7 | 4,7 | 4,8 | 4,8 | 4,9 | 4,9 | 4,9 | 5,0 | 5,0 | – |
| **ST 6,3** | 1,8 | from 100 | – | – | – | – | – | – | – | – | – | – | 4,9 | 4,9 | 4,9 | 4,9 | 4,9 | 4,9 | 4,9 | 5,2 | 5,3 | 5,5 | 5,5 |
| | | approx. 300 | – | – | – | – | – | – | – | – | – | – | 5,0 | 5,1 | 5,2 | 5,3 | 5,4 | 5,5 | 5,6 | 5,7 | 5,7 | 5,8 | 5,8 |
| | | up to 500 | – | – | – | – | – | – | – | – | – | – | 5,4 | 5,4 | 5,5 | 5,6 | 5,6 | 5,7 | 5,7 | 5,8 | 5,8 | 5,8 | 5,8 |

## Minimum breaking torque for sheet metal screws

ISO 2702 (old DIN 267, part 12)

| nominal-Ø [mm] | ST 2,2 | ST 2,6 | ST 2,9 | ST 3,3 | ST 3,5 | ST 3,9 | ST 4,2 | ST 4,8 | ST 5,5 | ST 6,3 | ST 8 | ST 9,5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum breaking torque[1] [Nm] | 0,45 | 0,9 | 1,5 | 2 | 2,7 | 3,4 | 4,4 | 6,3 | 10 | 13,6 | 30,5 | 68 |

[1] Torsional strength with clamping arrangement determined as per ISO 2702.

### Tightening torque for sheet metal screws

Approximate values have to be derived from the ISO 2702 (old DIN 267, part 12).

### Reference values for tightening torque:

MA = approx. 80 % of the minimum torsional strength resp. the stripping-torque with failure cause into screw or component.

The maximum thread forming torque should not be higher than 50 % of the stripping-torque (minimum torsional strength of the screw).

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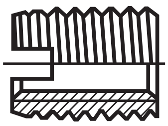
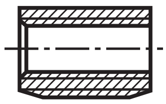
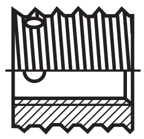
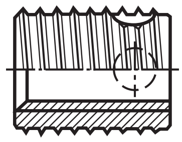
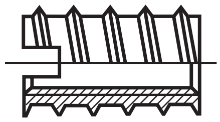
## Selection criteria for self-tapping Ensat® inserts

### Grouping of materials, types and finishes

| | | | | |
|---|---|---|---|---|
|  |  |  |  |  |
| Ensat®<br>Type 302 | Ensat®<br>Type 305 | Ensat®<br>Type 307/308 | Ensat®<br>Type 337/338 | Ensat®<br>Type 309 |

| Material Group | Base material | Recommended works standards | Recommended Ensat® version |
|---|---|---|---|
| I | Tempered light metal alloys<br>more than 350 N/mm² tensile strength | 302/337<br>307/338<br>308 | Steel case-hardened<br>zinc plated |
| | Cast iron in higher hardness range<br>Brass, bronze and other non-ferrous metals. | 302 | Steel case-hardened<br>zinc plated |
| II | Light metal alloys up to<br>350 N/mm² tensile strength | 302/337<br>307/338<br>308 | Steel case-hardened<br>zinc plated |
| | Cast iron | 302 | Steel case-hardened<br>zinc plated |
| | Brittle-rigid condensation resin plastics and<br>high-grade synthetic resins | 302/337<br>307/338<br>308 | Steel case-hardened<br>zinc plated or Brass |
| III | Light metal alloys up to<br>300 N/mm² tensile strength | 302/337<br>307/338<br>308 | Steel case-hardened<br>zinc plated |
| | Soft cast iron | 302 | Steel case-hardened<br>zinc plated |
| | Condensation resin plastics of<br>medium hardness | 302/337<br>307/338<br>308 | Steel case-hardened<br>zinc plated |
| | | 302 | Brass |
| IV | Light metal alloys up to<br>250 N/mm² tensile strength | 302 | Steel case-hardened<br>zinc plated |
| | Soft metals and light metal alloys up to<br>180 N/mm² tensile strength | 302 | Steel case-hardened<br>zinc plated<br>or stainless steel A1 |
| | Soft condensation resin<br>plastics laminates with resin bond | 302 | Steel case-hardened<br>zinc plated<br>or Brass or stainless steel A1 |
| | Soft polymerisation-, polycondensation- and<br>polyaddition plastic materials<br>Hardwoods | 302 | Steel case-hardened<br>zinc plated<br>or Brass or stainless steel A1 |
| V | Hardwoods | 309 | Brass |
| VI | Softwoods and plywood<br>Wood fiber materials | 309 | Brass |
| VII | Soft polymerisation-, polycondensation- and<br>polyaddition plastic materials | 305 | Brass |

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# Construction recommendations

## Recommended pilot hole diameters and material thickness/ blind hole depths for threaded inserts Ensat®

The recommended hole diameter depends on the Ensat® external thread, the strength and the physical characteristics of the work-piece material.

Hard and brittle materials require a larger hole than soft and flexible ones. Whenever necessary, the most suitable hole diameter should be determined through application testing.

### Ensat® Type 302

| Thread | Hole diameter D [mm] | | | | Material thickness $A_{min}$ | Blind hole depth $B_{min}$ |
|---|---|---|---|---|---|---|
| | For material groups | | | | | |
| | I | II | III | IV | | |
| | Attainable percentage of overlapping threads | | | | | |
| | 30%–40% | 40%–50% | 50%–60% | 60%–70% | | |
| M2,5 | 4,3–4,2 | 4,2–4,1 | 4,1 | 4,1–4 | 6 | 8 |
| M2,6 | 4,3–4,2 | 4,2 | 4,1 | 4,1–4 | 6 | 8 |
| M3 | 4,8–4,7 | 4,7 | 4,6 | 4,6–4,5 | 6 | 8 |
| M3,5 | 5,7–5,6 | 5,6–5,5 | 5,5–5,4 | 5,4–5,3 | 8 | 10 |
| M4 | 6,2–6,1 | 6,1–6 | 6–5,9 | 5,9–5,8 | 8 | 10 |
| M5 | 7,6–7,5 | 7,5–7,3 | 7,3–7,2 | 7,2–7,1 | 10 | 13 |
| M6a | 8,6–8,5 | 8,5–8,3 | 8,3–8,2 | 8,2–8,1 | 12 | 15 |
| M6 | 9,4–9,2 | 9,2–9 | 9–8,8 | 8,8–8,6 | 14 | 17 |
| M8 | 11,4–11,2 | 11,2–11 | 11–10,8 | 10,8–10,6 | 15 | 18 |
| M10 | 13,4–13,2 | 13,2–13 | 13–12,8 | 12,8–12,6 | 18 | 22 |
| M12 | 15,4–15,2 | 15,2–15 | 15–14,8 | 14,8–14,6 | 22 | 26 |
| M14 | 17,4–17,2 | 17,2–17 | 17–16,8 | 16,8–16,6 | 24 | 28 |
| M16 | 19,4–19,2 | 19,2–19 | 19–18,8 | 18,8–18,6 | 22 | 27 |
| M20 | 25,4–25,2 | 25,2–25 | 25–24,8 | 24,8–24,6 | 27 | 32 |
| M24 | 29,4–29,2 | 29,2–29 | 29–28,8 | 28,8–28,6 | 30 | 36 |

### Ensat® Type 307/308/337/338

| Thread | Hole diameter D [mm] | | | Material thickness $A_{min}$ | Blind hole depth $B_{min}$ |
|---|---|---|---|---|---|
| | For material groups | | | | |
| | I | II | III | | |
| | Attainable percentage of overlapping threads | | | | |
| | 50%–60% | 60%–70% | 70%–80% | | |
| M3,5 | 5,7–5,6 | 5,6 | 5,6–5,5 | 5/8 | 7/10 |
| M4 | 6,2–6,1 | 6,1 | 6,1–6 | 6/8 | 8/10 |
| M5 | 7,7–7,6 | 7,6–7,5 | 7,5–7,4 | 7/10 | 9/13 |
| M6 | 9,6–9,5 | 9,5–9,4 | 9,4–9,3 | 8/12 | 10/15 |
| M8 | 11,5–11,3 | 11,3–11,2 | 11,2–11,1 | 9/14 | 11/17 |
| M10 | 13,5–13,3 | 13,3–13,2 | 13,2–13,1 | 10/18 | 13/22 |
| M12 | 15,4–15,2 | 15,2–15,1 | 15,1–15 | 12/22 | 15/26 |
| M14 | 17,4–17,2 | 17,2–17,1 | 17,1–17 | 14/24 | 17/28 |

### Ensat® Type 309

| Thread | Hole diameter D [mm] | | Material thickness $A_{min}$ | Blind hole depth $B_{min}$ |
|---|---|---|---|---|
| | For material groups | | | |
| | V | VI | | |
| | Attainable percentage of overlapping threads | | | |
| | 85%–90% | 90%–95% | | |
| M2,5 | 3,8–3,6 | 3,6–3,5 | 6 | 8 |
| M3 | 4,3–4,2 | 4,2–4,1 | 6 | 8 |
| M4 | 5,3–5,2 | 5,2–5,1 | 10 | 13 |
| M5 | 6,9–6,7 | 6,7–6,6 | 12 | 15 |
| M6 | 7,9–7,7 | 7,7–7,6 | 14 | 17 |
| M8 | 10,3–10,1 | 10,1–9,9 | 20 | 23 |
| M10 | 12,8–12,6 | 12,6–12,4 | 23 | 26 |
| M12 | 15,8–15,6 | 15,6–15,4 | 26 | 30 |

### Ensat® Type 305

| Thread | Hole diameter D [mm] | Material thickness $A_{min}$ | Blind hole depth $B_{min}$ |
|---|---|---|---|
| | For material groups | | |
| | VII | | |
| | Attainable percentage of overlapping threads | | |
| | 85%–90% | | |
| M3 | 4,6–4,7 | 6 | 7 |
| M4 | 6–6,1 | 8 | 9 |
| M5 | 7,3–7,4 | 10 | 11 |
| M6 | 9–9,2 | 14 | 15 |

### The pilot hole can be drilled or formed during die-casting

Countersinking the hole is usually not necessary; however it would facilitate installation and possibly prevent damage to the workpiece surface. It also would enable the insert to be flush with the work-piece.

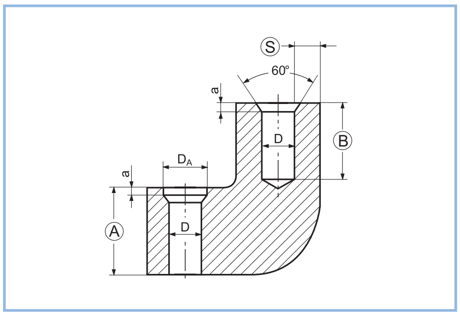
**Material thickness:**
Length of Ensat® = shortest permissible material thickness Ⓐ

**Blind hole depth:** Minimum depth Ⓑ

**Minimum wall thickness:** The wall thickness is dependant upon the hardness and/or strength of the workpiece material.

**Recommendation for light metals:** Ⓢ $\geq 0{,}2$ to $\geq 0{,}6\ d_2$
**Recommendation for cast iron:** Ⓢ $\geq 0{,}3$ to $\geq 0{,}5\ d_2$

$d_2$ = Outside diameter [mm] of Ensat® insert




$D_A$ = + 0,2 to 0,4 mm
a = 1 to 1,5 x the pitch of the external thread

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## Internal drives for screws

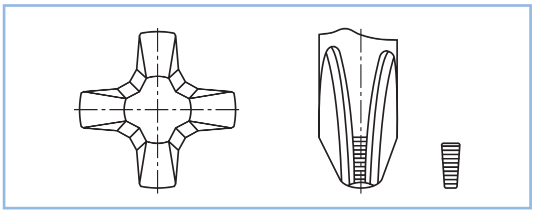
Technical progress and economic factors have resulted in the increasing replacement of slotted head screws by other internal drive systems.

It is very important today to take into account the most frequently used drives and their possibilities in design, logistics, procurement and assembly.

### Cross recess H (Phillips)

according to ISO 4757

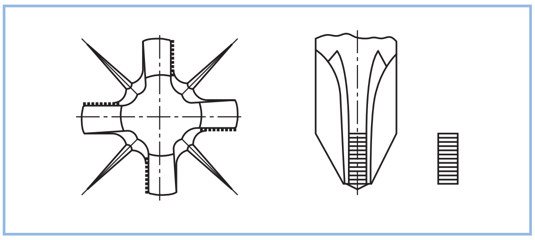
– The Phillips cross recessed head is the world's most widely used system.
– Has a conventional cruciform recess with all walls inclined, the end of the screwdriver having trapezoid webs.
– The general dimensions are given in the product information of the respective catalogue group.



### Cross recess Z (Pozidriv)

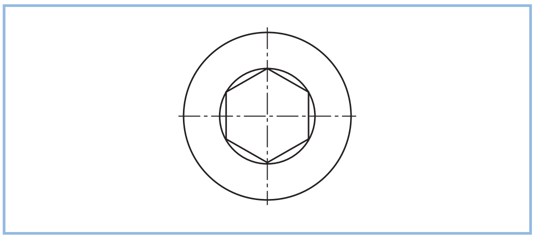
according to ISO 4757

– The Pozidriv cross recessed head is used principally in Europe.
– The four «tightening walls» of the cruciforme recess in contact with the screwdriver when tightening, are perpendicular. The other walls are inclined. This can improve assembly if the recess production is reliable. The Pozidriv screwdriver has rectangular webs at its extremity.
– The general dimensions are given in the product information of the respective catalogue group.



### Hexagon socket

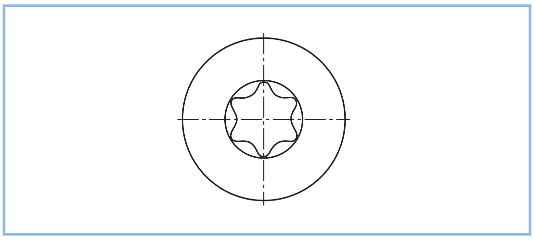
– Screws with hexagon socket head have proved their worth in the machine and apparatus construction fields.
– The width across flats of hexagon socket head screws is smaller than the WAF of hexagon head screws, permitting more economic design with smaller sizes.
– The general dimensions are given in the product information of the respective catalogue group.



### Hexalobular socket

according to ISO 10664

– The notion of a drive with hexalobular sockets are a decisive step in developing drives better adapted to manual and automated assembly. This drive is becoming increasingly popular throughout the world.
– Compared to drives like cross recesses and conventional hexagon sockets, this system is characterized by a lower risk of deterioration and a lower pressure force requirement. The typical «cam out» slipping of the tool has hence been eliminated and the force transmission improved.
– The general dimensions are given in the product information of the respective catalogue group.



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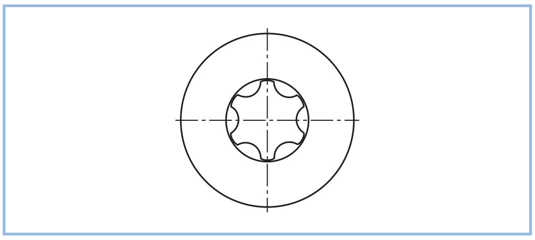
# Construction recommendations

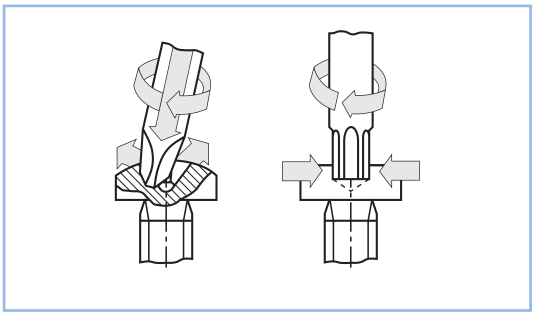
## Torx plus®

- The Torx plus® drive is defined by ellipses and represents an improvement over the original hexalobular system which is defined by a series of radii.
- The Torx plus® system is compatible with the tools provided for the (Torx®) hexalobular system. However, the specific geometric benefits of Torx plus® can only optimize assembly when using the Torx plus® screwdriver bits (tool).
- The general dimensions are given in the product information of the respective catalogue group.

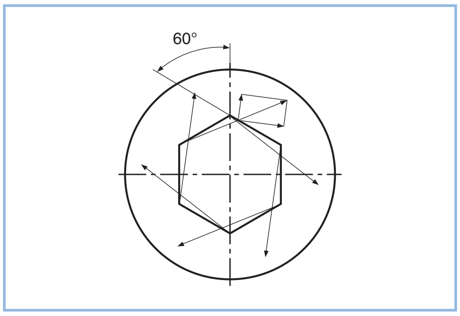


## Technical advantages of hexalobular socket and Torx plus® drives and their economic benefit

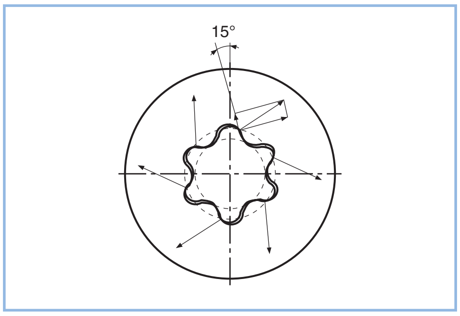
- No need for pressure force as it is necessary when using cross recessed drives.
- Can accept the tightening torques for all property classes.
- No deterioration of the internal drive; hence reliable unscrewing. Very low assembly tool wear.
- High rationalisation potential for the assembly technique, as the drive is suitable for all types of screw.
- Economic head from the aspect of size, form and material, corresponding to cheese head screws DIN 84 and DIN 7984, however able to cope with high stresses with respect to permissible surface pressure.
- No problem assembling round head screws according to ISO 7380 and recessed flat head screws DIN 7991. The high property class 010.9 of these screws permitting increased strength of the hexagon socket can be reduced to property class 08.8.



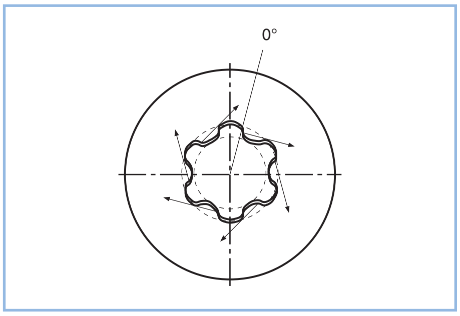
## The hexalobular socket and the Torx plus® systems have benefits due to their design parameters




Force transmission angle of 60° with hexagon socket drives




Force transmission angle of 15° with hexalobular socket drives




Force transmission angle of 0° with Torx plus® drives

- The effective transmission angle of the hexalobular socket is 15° while that of a Torx plus® is 0°. A 0° drive angle has the advantage that the entire force acting on the drive is used to drive the screw in. The geometries of the hexalobular socket and the Torx plus® therefore extend the service life of the screwdriver bits by up to 100%.
- The cross section of the Torx plus® drive is larger compared to the hexalobular drive system. Therefore the torsional strength of the driving tool is increased.
- The good force transmission enables low penetration depths.

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