FDS®
The Flow-Drill Screw for
High-Strength Sheet Joints
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Convincing facts about the FDS® joint

- removable and high-strength screw joint, without part preparations like punching or drilling

- no problems regarding hole overlapping of clearance and pilot hole

- no material waste while forming the through draught / no chips during thread forming

- several metric threads are engaged

- high safety margin due to large distance between installation and stripping torque (high assembly reliability)

- high shearing strength and pull-out force

- assembly in different sheet surfaces is possible

- high break loose torque and vibration resistance

- repeat assemblies possible with standard machine screws

- earthing assemblies (according to DIN VDE 0700) are practical

- easy to disassemble and recyclable

- low overall joint costs
Secure screw joints for steel and aluminium sheets

Due to its good processing and performance characteristics, steel is still the most important material in the sheet metal processing industry but the competition from lighter materials, such as aluminium, is increasing. For this reason the steel industry developed a number of new sheet materials over the last few years which feature high strengths and at the same time good forming characteristics. In addition to the typical deep-drawn, mild, unalloyed steels for coldforming (acc. to DIN EN 10130) the micro-alloyed thin sheets with higher yield strength H240M (ZStE 260) – H400M (ZStE 420) according to DIN EN 10268 (SEW093) and the dual phase steel type DP according to SEW 097, part 2, should be mentioned, since both materials play a significant role in the field of high strength sheet assemblies.

For forgeable aluminium alloy in the automotive industry mainly thermal hardenable AlMgSi alloys from the 6000 group in the strength grade T4 up to T6 are used in addition to the non-hardenable alloys of the 500 group. The T4 / T5 grades are preferred for sheet material and T6 for the extrusion profiles. The maximum utilisation of the respective steel, and aluminium properties often requires a reconsideration of the commonly used assembly methods in particular when joining different materials.

The flow drilling FDS® Screw enables a higher-strength joint due to larger thread engagement in the formed draught.

The female metric thread, formed without producing chips during fastening, is true to gauge and for that reason a common metric screw can be used in case of repairs.

Due to the tight fitting engagement of several threads the screw joint is waterproof and gas-tight and it can transfer high pull-out and shear forces. The heat development during flow-drilling is harmless, because it is below the recrystallisation temperature of the assembly materials and is counted towards the low temperature joining methods. The low remaining temperature is sufficient to shrink the formed draught onto the screw after assembly which guarantees a high dynamic safety.

For this reason additional safety elements, such as adhesive coatings, can be eliminated.

Since component preparations, such as pre-drilling or punching are not necessary, known tolerance problems and lining up of clearance holes are a thing of the past. The one-sided accessibility of the component enables assembly into hollow profiles or extrusions similar to other joining methods.

Example in practice: automotive industry

Example in practice: white-good industry
Stages of the FDS® assembly

1. Warming up of the sheet through end load and high rotation speed
2. Penetration into the material
3. Forming of the through draught
4. Chipless forming of female machine thread
5. Engagement of full threads
6. Tightening with the pre-set torque

Temperature pattern of a FDS® joint

1. Heating
2. Penetrating
3. Through draught forming
4. Thread forming
5. Engagement of full threads
6. Tightening

Fastening parameter

Material: 0,8 mm steel plate
DC 04 (without pilot hole)

Screw: FDS® M 3,5

Driver speed: 2300 rpm
Due to the numerous possible sheet metal applications, several styles of the FDS® Screw have been developed.

The Standard type is preferred for automated assembly without pilot hole.

For assembly with hand-held fastening equipment a pilot hole in combination with the PKS Type is useful.

For manual assembly without pilot hole the FDS® Type BS is recommended. In this case please consider the chipping that occurs during drilling.

With the PKS and BS types, a pilot hole or pre-drilling facilitates the penetration of the sheet metal, and a reduction of the end load by 50% is possible. The diameter of pilot hole or the drill point is relatively small and therefore the remaining sheet metal also forms a draught.

The diagram on page 11 shows the pilot hole diameters.

Degree of dependence of the end load on screw point design and pilot hole at constant assembly times.
<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
<th>PKS</th>
<th>BS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw material</td>
<td>Case hardened mild steel</td>
<td>Case hardened mild steel</td>
<td>case hardened mild steel</td>
</tr>
<tr>
<td></td>
<td>Through hardened steel through hardened steel + inductive hardening</td>
<td>Through hardened steel through hardened steel + inductive hardening</td>
<td></td>
</tr>
<tr>
<td>Surfaces</td>
<td>Chrom VI-free surfaces:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>zinc clear / blue passivated</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>zinc clear / blue passivated + EJOSEAL (240h resistance to Zn-corrosion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnFe or ZnNi, transparent passivated (with or without black top coats)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>zinc flake coatings (with or without black top coats)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ZnNi / black passivated</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Different plating upon request!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td>fastening without prepunching</td>
<td>fastening with prepunching</td>
<td>fastening without prepunching</td>
</tr>
<tr>
<td>Installation material</td>
<td>steel 0,4 - 1,8 mm</td>
<td>steel 0,4 - 2,0 mm</td>
<td>steel 0,4 - 1,5 mm</td>
</tr>
<tr>
<td></td>
<td>aluminium 0,8 - 5,0 mm</td>
<td>aluminium 0,8 - 4,0 mm</td>
<td>aluminium 0,8 - 2,0 mm</td>
</tr>
<tr>
<td></td>
<td>magnesium 0,8 - 4,0 mm</td>
<td>magnesium 0,8 - 4,0 mm</td>
<td>magnesium 0,8 - 2,0 mm</td>
</tr>
<tr>
<td></td>
<td>stainless steel 0,4 - 1,5 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characteristics</td>
<td>tolerance-free assembly, because no misalignment with clearance hole possible</td>
<td>due to the bigger clearance hole compared to the smaller pilot hole, some tolerances can be compensated (S. 11)</td>
<td>tolerance-free assembly, because no misalignment with clearance hole possible</td>
</tr>
<tr>
<td></td>
<td>suited especially for automated assembly</td>
<td>preferable for manual assembly</td>
<td>suited for automated and manual assembly</td>
</tr>
<tr>
<td></td>
<td>extremely high joint strength</td>
<td>low end load</td>
<td>low end load</td>
</tr>
<tr>
<td></td>
<td>one-sided assembly</td>
<td>one-sided assembly</td>
<td>one-sided assembly</td>
</tr>
<tr>
<td></td>
<td>ideal screw for safe assembly and dynamic loads</td>
<td>the through draught is about twice as high as the original sheet metal thickness</td>
<td>the through draught is about twice as high as the original sheet metal thickness</td>
</tr>
<tr>
<td></td>
<td>the through draught is about 3 times as high as the original sheet metal thickness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Designs**

**WN 2141**

![Diagram](image1)

**WN 2142**

![Diagram](image2)

**WN 2143**

![Diagram](image3)

**WN 2147**

![Diagram](image4)

**H-cross recess**  **Z-cross recess**  **TORX®**  **TORX® / AUTOSERT®**

In case of manual assembly with TORX® it is recommended to use a TORXALIGN® bit, e.g. STICK FIT bits by TORX PLUS® drives.

All cross recess and TORX® drives are also available as combi drives.

**FDS®**

<table>
<thead>
<tr>
<th>Nominal-Ø</th>
<th>M 3</th>
<th>M 3,5</th>
<th>M 4</th>
<th>M 5</th>
<th>M 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>External thread-Ø d₁</td>
<td>3,0</td>
<td>3,5</td>
<td>4,0</td>
<td>5,0</td>
<td>6,0</td>
</tr>
</tbody>
</table>

**WN 2141**

| Head-Ø D | 7,50 | 8,50 | 10,00 | 12,00 | 14,00 |
| Head height K | 2,40 | 2,50 | 3,20 | 4,00 | 4,60 |
| Washer thickness s | 0,80 | 0,90 | 1,10 | 1,30 | 1,50 |
| H-cross recess penetration depth min. t | 1,07 | 1,33 | 1,98 | 2,24 | 2,84 |
| H-cross recess penetration depth max. t | 1,70 | 1,96 | 2,61 | 2,90 | 3,50 |
| Z-cross recess penetration depth min. t | 1,08 | 1,40 | 2,01 | 2,27 | 2,91 |
| Z-cross recess penetration depth max. t | 1,54 | 1,86 | 2,47 | 2,73 | 3,37 |
| Cross size H/Z | 1 | 2 | 2 | 3 | 3 |

**WN 2142**

| Head-Ø D | 6,00 | 7,00 | 8,00 | 10,00 | 12,00 |
| Head height K | 2,40 | 2,70 | 3,10 | 3,80 | 4,60 |
| H-cross recess penetration depth min. t | 1,70 | 1,74 | 2,04 | 2,77 | 3,03 |
| H-cross recess penetration depth max. t | 2,00 | 2,24 | 2,54 | 3,27 | 3,53 |
| Z-cross recess penetration depth min. t | 1,68 | 1,65 | 1,90 | 2,64 | 3,02 |
| Z-cross recess penetration depth max. t | 1,93 | 2,11 | 2,36 | 3,10 | 3,48 |
| Cross size H/Z | 1 | 2 | 2 | 3 | 3 |

**WN 2143**

| Head-Ø D | 5,60 | 6,50 | 7,50 | 9,20 | 11,00 |
| Cyl. head height c_max | 0,55 | 0,55 | 0,65 | 0,75 | 0,85 |
| Radius R_max | 0,80 | 0,95 | 1,00 | 1,30 | 1,60 |
| H-cross recess penetration depth min. t | 1,50 | 1,40 | 1,90 | 2,10 | 2,80 |
| H-cross recess penetration depth max. t | 1,80 | 1,90 | 2,40 | 2,60 | 3,30 |
| Z-cross recess penetration depth min. t | 1,48 | 1,34 | 1,60 | 2,05 | 2,46 |
| Z-cross recess penetration depth max. t | 1,73 | 1,80 | 2,06 | 2,51 | 2,92 |
| Cross size H/Z | 1 | 2 | 2 | 2 | 3 |

**WN 2147**

| Washer-Ø D | 7,50 | 8,30 | 9,00 | 11,00 | 13,00 |
| Head height K | 3,00 | 3,40 | 3,80 | 4,30 | 5,00 |
| Washer thickness s | 0,60 | 0,80 | 0,80 | 1,00 | 1,20 |
| Width across flats A/F | 5,00 | 5,50 | 5,50 | 7,00 | 8,00 |
### Ordering Example:

Description of FDS® screw Ø 4 mm and length 20 mm:

- **a)** type Standard with Z-cross recess according to WN 2141:
  
  \[ \text{FDS® screw M4 x 20 WN2141-Z} \]

- **b)** type PKS with TORX® recess according to WN 2152:
  
  \[ \text{FDS® screw M4 x 20 PKS WN2152} \]

- **c)** type BS with hexagonal heat according to WN 2147:
  
  \[ \text{FDS® screw M4 x 20 BS WN2147} \]

### Designs

- **WN 2151**
  - Head Ø: 7,50, 8,50, 10,00, 12,00, 14,00
  - Head height: 2,70, 2,90, 3,60, 3,90, 4,80
  - Washer thickness: 0,70, 0,80, 1,00, 1,20, 1,40
  - Torx: A\text{max} = 2,80
  - Penetration depth: t\text{max} = 1,30

- **WN 2152**
  - Head Ø: 6,00, 7,00, 8,00, 10,00, 12,00
  - Head height: 2,70, 2,90, 3,60, 3,90, 4,80
  - Torx: A\text{max} = 2,80
  - Penetration depth: t\text{max} = 1,30

- **WN 2154**
  - Head Ø: 5,60, 6,50, 7,50, 9,20, 11,00
  - Cyl. Head height: c\text{max} = 0,60
  - Torx: A\text{max} = 2,80
  - Penetration depth: t\text{max} = 1,10

### Special variations / Examples

Special variations are available.
Please contact the ATF application engineers for assistance with your multifunctional design.
In many applications the FDS® can be used with existing products.

The following notes are for the design of existing and new products.

The **usable thread length** \( b \) of FDS® screws is dependent on the part’s thickness \( S_1 \) and the metal sheet thickness \( S_2 \).

It is given by:

\[
\begin{align*}
    b &= S_1 + 3 \times S_2 \quad \text{without prepunching (type Standard)} \\
    b &= S_1 + 2 \times S_2 \quad \text{with prepunching (type PKS and BS)}
\end{align*}
\]

The corresponding nominal screw length \( L \) can be taken from the accompanying table below.

**Example**

\[
\begin{align*}
    S_1 &= 4,50 \text{ mm}, \quad S_2 = 0,75 \text{ mm} \\
    \text{without prepunching} &\quad b = (4,50 + 3 \times 0,75) \text{ mm} = 6,75 \text{ mm} \\
    \text{with prepunching} &\quad b = (4,50 + 2 \times 0,75) \text{ mm} = 6,00 \text{ mm}
\end{align*}
\]

For an FDS® M5 Standard (without pilot-hole) the recommendation (according to the diagram below) is an effective thread length of \( b = 6,90 \) mm with a corresponding nominal length of \( L = 18 \) mm.

For assembly with pilot hole a FDS® M5 x 14 PKS with an effective thread length of \( b = 6,20 \) mm and a nominal length of \( L = 14 \) mm.

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### Manufacturing range

<table>
<thead>
<tr>
<th>FDS® screw</th>
<th>M3</th>
<th>M3,5</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length ( L ) [mm]</td>
<td>Standard PKS BS</td>
<td>Standard PKS BS</td>
<td>Standard PKS BS</td>
<td>Standard PKS BS</td>
<td>Standard PKS BS</td>
</tr>
<tr>
<td>9 + 0,8</td>
<td>2,40</td>
<td>4,70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 + 0,8</td>
<td>3,40</td>
<td>5,70</td>
<td>2,40</td>
<td>4,90</td>
<td>4,60</td>
</tr>
<tr>
<td>12 + 0,8</td>
<td>5,40</td>
<td>7,70</td>
<td>4,40</td>
<td>6,90</td>
<td>6,60</td>
</tr>
<tr>
<td>14 + 0,8</td>
<td>7,40</td>
<td>9,70</td>
<td>6,40</td>
<td>8,90</td>
<td>8,60</td>
</tr>
<tr>
<td>16 + 0,8</td>
<td>9,40</td>
<td>11,70</td>
<td>8,40</td>
<td>10,90</td>
<td>10,60</td>
</tr>
<tr>
<td>18 + 0,8</td>
<td>11,40</td>
<td>13,90</td>
<td>10,40</td>
<td>12,90</td>
<td>12,60</td>
</tr>
<tr>
<td>20 + 0,8</td>
<td>12,40</td>
<td>14,90</td>
<td>14,60</td>
<td>11,10</td>
<td>13,70</td>
</tr>
<tr>
<td>25 + 0,8</td>
<td></td>
<td></td>
<td>16,10</td>
<td>18,70</td>
<td>18,40</td>
</tr>
<tr>
<td>30 + 0,8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 + 1,0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 + 1,0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45 + 1,0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 + 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Special lengths upon request.

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\( \cdots \cdots \cdots \ cdots \) = minimum length for countersunk heads
Recommended clearance hole $d_C$ [mm]
Flow-drilling with the FDS® Screw causes a small portion of the formed part to flow against the fastening direction and to create a bulge which as to be absorbed by the clearance hole of the component to be fastened. For this reason we recommend the following hole diameter.

<table>
<thead>
<tr>
<th>FDS®</th>
<th>M3</th>
<th>M3,5</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d_C$</td>
<td>3.6 - 4.0</td>
<td>4.3 - 4.8</td>
<td>5.1 - 5.7</td>
<td>6.7 - 7.4</td>
<td>8.2 - 9.1</td>
</tr>
</tbody>
</table>

Recommended hole diameter $d_V$ [mm] for the PKS type
The optimum hole diameter depends on the respective range of requirements on the joint and should be specified according to the application.

<table>
<thead>
<tr>
<th>FDS®</th>
<th>M3</th>
<th>M3,5</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d_V$</td>
<td>0.5</td>
<td>1.0 - 1.4</td>
<td>1.2 - 1.7</td>
<td>1.5 - 2.0</td>
<td>1.8 - 2.5</td>
</tr>
<tr>
<td></td>
<td>0.63</td>
<td>1.2 - 1.6</td>
<td>1.4 - 1.8</td>
<td>1.6 - 2.2</td>
<td>1.8 - 2.5</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
<td>1.6 - 1.8</td>
<td>1.6 - 2.0</td>
<td>1.8 - 2.5</td>
<td>2.0 - 2.8</td>
</tr>
<tr>
<td></td>
<td>0.88</td>
<td>1.8 - 2.2</td>
<td>1.8 - 2.3</td>
<td>2.0 - 2.6</td>
<td>2.2 - 3.0</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>-</td>
<td>1.8 - 2.4</td>
<td>2.2 - 2.8</td>
<td>2.6 - 3.4</td>
</tr>
<tr>
<td></td>
<td>1.25</td>
<td>-</td>
<td>-</td>
<td>2.4 - 3.0</td>
<td>3.0 - 3.8</td>
</tr>
<tr>
<td></td>
<td>1.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.4 - 4.2</td>
</tr>
<tr>
<td></td>
<td>&gt;1.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.2 - 4.6</td>
</tr>
</tbody>
</table>

* With lasered holes please consider hole edge hardening.
Valid for sheet metal / sheet metal joints made of mild, unalloyed steels for coldforming acc. to DIN EN 10130 (DC01 - DC07)

Note for manual assembly
For manual assembly into sheet metal thicker than:
steel > 0,80 mm; Aluminium > 1,25 mm a higher end load is necessary. As a result we recommend the use of either a pilot hole or our FDS® type BS.
Assembly Recommendations

Fastening
During the fastening process the following graph of the installation torque can be observed over time.

1. Through draught forming
2. Thread forming
3. Engagement of full threads
4. Tightening

The fastening time necessary for FDS® mainly depends upon the flowdrilling process.

Parameters are:
- Screw diameter
- Type of screw point
- Driver tool speed
- Sheet thickness
- Sheet quality / material specification
- End load
- Part preparation yes / no

We will gladly determine the respective data for your individual application.

Fastening equipment selection
A high driver speed and defined end load are necessary for the flow-drilling and for the thread forming and for tightening a high torque. This requires special tools that have been developed in cooperation with several manufacturers. Most manufacturers for manually operated and automatic fastening equipment offer screw drivers with speeds from 2000 to 5000 rpm.

The necessary assembly data such as driver speed and tightening torque depend on
- Sheet thickness
- Material strength
- Surface treatment
- Material of the connecting surface
- Requirements of the screw joint

For manual assembly pneumatic screw drivers with torque controlled shut-off clutch.

For automated assembly both pneumatic and electric spindels (brushless DC or AC) are suitable.

To determine the parameters assembly tests in our application technology laboratory can be carried out.

Robot-aided fastening system by Weber Schraubautomaten
In the frame of the suitability examination of joining methods for high-strength sheet steel the University Paderborn (Germany), has tested the strength values of an FDS® joint regarding peeling and shearing strength.

The strength properties of fastening with FDS® were compared to other joining methods.

In addition to the two diagrams the strength value of an FDS® joint with additional one-component adhesive (hybrid) is pictured.

peeling strength $F_m$ and energy absorption $W_{0.3F_m}$ of different joining methods in steel (ZStE 340)

shearing strength $F_m$ and energy absorption $W_{0.3F_m}$ of different joining methods in steel (ZStE 340)
In order to fully utilise the material properties of high-strength sheet steel, the selection of suitable joining methods is decisive.

Spot-welded samples of dual phase steel DP-K30/50 compared to a soft non-alloy steel DC 04 have up to 3 to 4 times longer service life.

The joining method with FDS® Screws increases the service life of the dual phase steel compared to the soft non-alloy steel by up to 10 times.

The smaller pitch of the Wöhler curve of the FDS® joint compared to spot welding also indicates a decreased notch sensitivity of the screw joint.

Dynamic strength of EJOT FDS® joints

Influence of joining method and sheet steel grade on the fatigue strength
Modern space frame structures have high demands on the joining technology in the body shell work because of the composite construction and the oftentimes one-sided accessibility.

While the clamped components for joining the FDS® screw to the Audi TT where still pre-punched, this pre-punching was omitted for the Audi R8. For this the fastening parameters where adjusted and the geometry of the FDS® screw below the screw head was optimised, since a small amount of the material flows towards the fastening direction. While in the past this through hole was used for taking up the displaced material it is now being absorbed by the increased space below the screw head.

To fasten the FDS® screw it is fed automatically into the nozzle of the robot guided fastening equipment. Prior to the actual fastening process the retainer, which is positioned in front of the nozzle, pushes on the joint in order to minimise cracking between the two components during the fastening process. The spindle speed is increased simultaneously to the application of the axial load. The screw point pierces both components and forms a metric female thread without chips. When the screw head connects to the surface the displaced material is taken up by the screw head. Until reaching the tightening torque the screw clamps the two components and ensures a much stronger joint due to the larger thread engagement.

The material arrangement when fastening without pilot hole should be “thin in thick” or “soft in hard” respectively, since higher tightening torques can be reached and gaps between the two components can be minimised.

**Stages of assembly:**
1. Warming up
2. Penetration into the material
3. Forming of the extrusion
4. Thread forming
5. Full thread engagement
6. Tightening

Application example:

- Aluminium sheet on extruded aluminium profile
- Composite construction - plastic on aluminium profile

**Process steps of the FDS® assembly without pilot hole**

(Source: Weber Schraubautomaten)