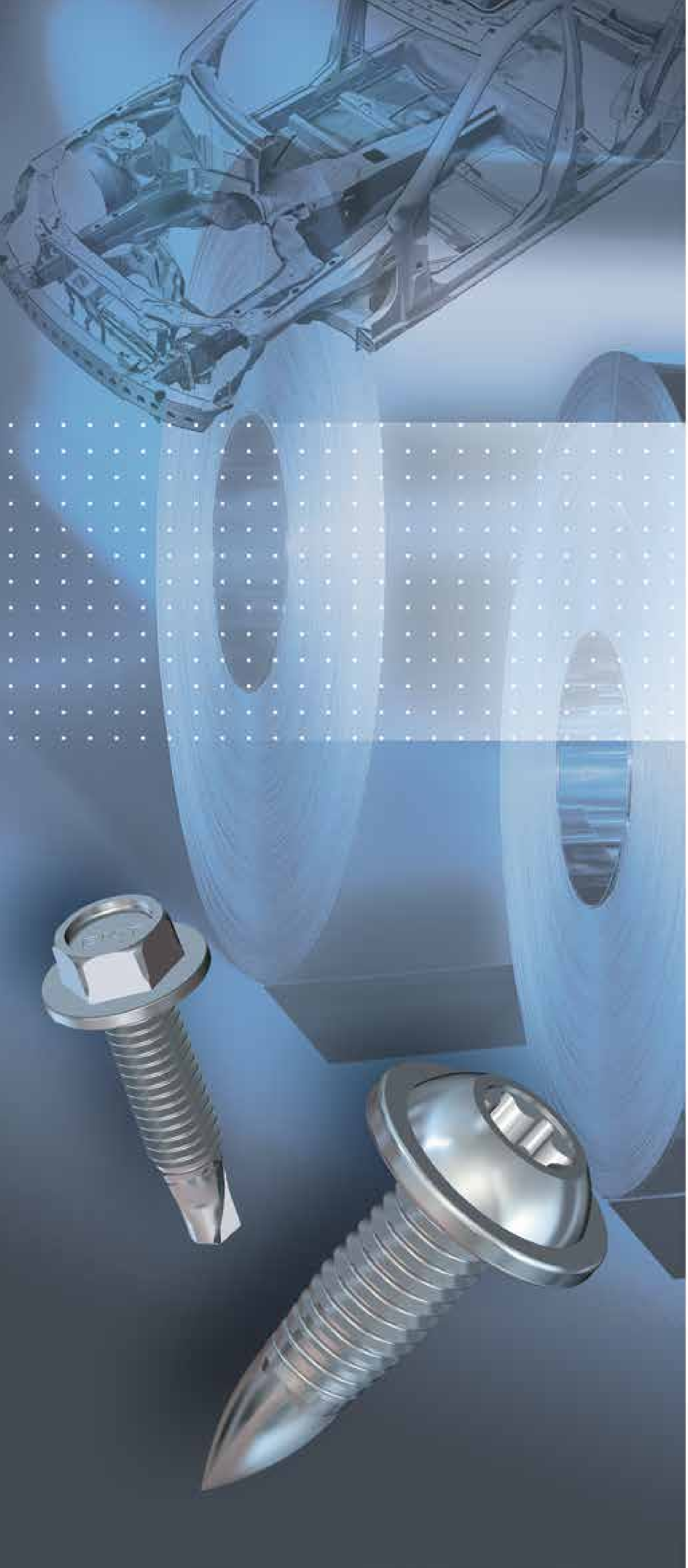


FDS®

The Flow-Drill Screw for High-Strength Sheet Joints

Content

Imprint

Editor:
EJOT GmbH & Co. KG
Industrial Fasteners Division
57319 Bad Berleburg
Germany

Print:

All technical data may be subject to technical improvements.

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.

Example in practice: white-good industry

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.

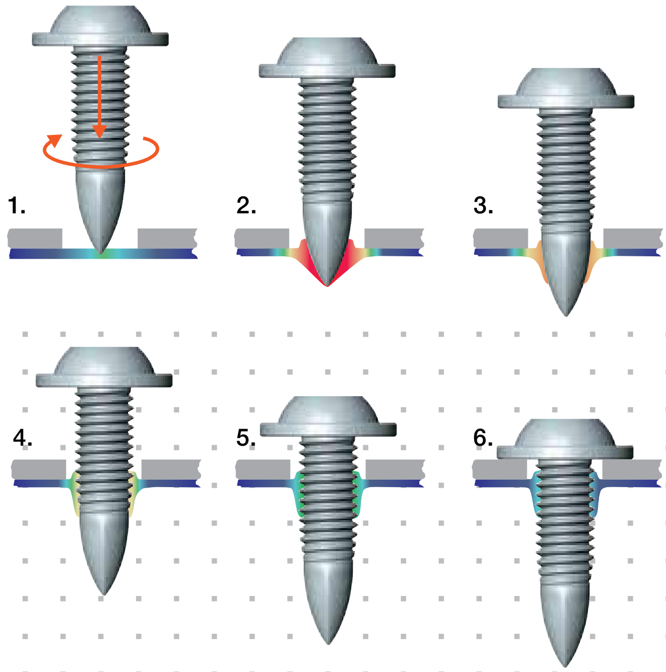
For this reason additional safety elements, such as adhesive coatings, can be eliminated.

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

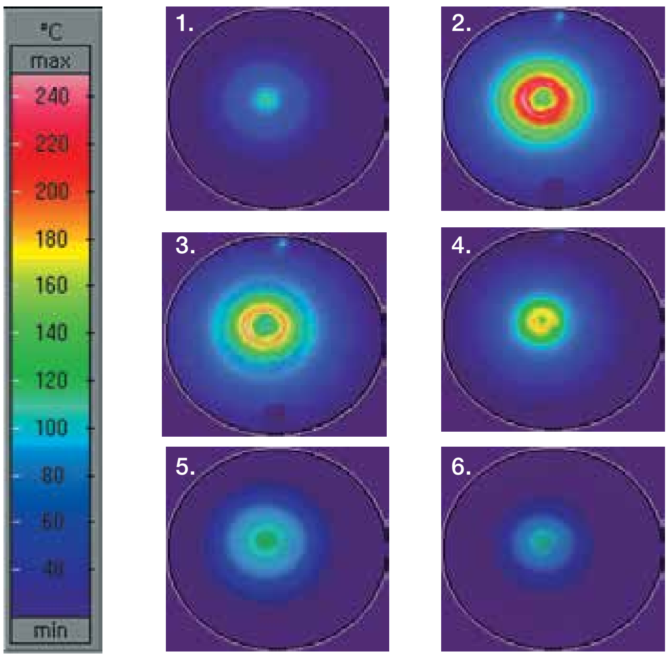
Stages of the FDS® assembly

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. Engangement 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.

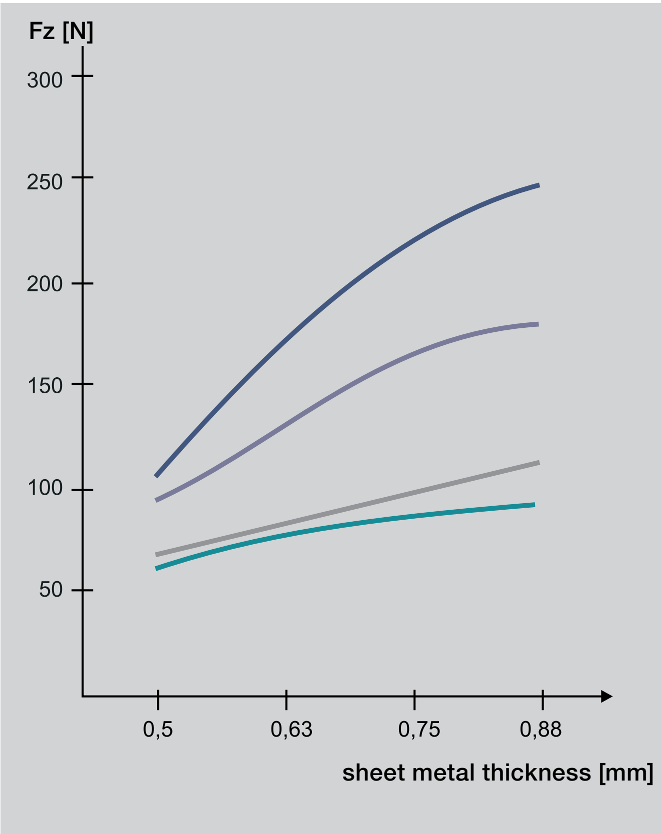
For assembly with hand-held fastening equipment a pilot hole in combination with the PKS Type is useful.

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

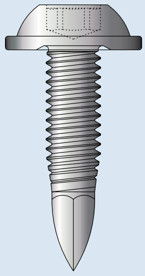
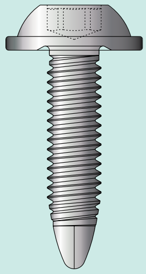
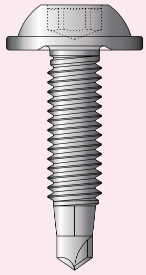
With the PKS and BS types, a pilot hole or pre-drilling facilitates the penetration of the sheet metal, and a reduction of the end load by 50 % is possible. The diameter of pilot hole or the drill point is relatively small and therefore the remaining sheet metal also forms a draught.

The diagram on page 11 shows the pilot hole diameters.

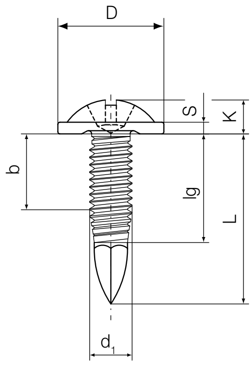
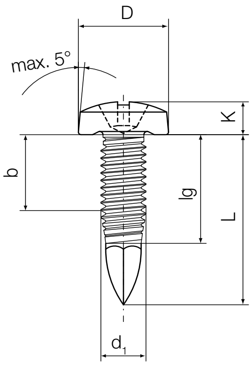
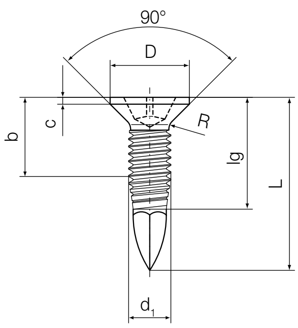
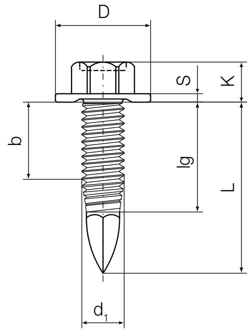
Degree of dependence of the end load on screw point design and pilot hole at constant assembly times.

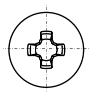
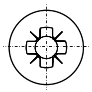
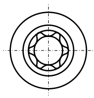
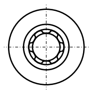


- type standard without prepunching
- type standard with punch mark 60°
- type PKS with prepunching
  at 0,50 mm sheet metal thickness Ø 2,2 mm
  at 0,63 mm sheet metal thickness Ø 2,4 mm
  at 0,75 mm sheet metal thickness Ø 2,6 mm
  at 0,88 mm sheet metal thickness Ø 2,8 mm
- type BS with drill point Ø 2,4 mm

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

Designations

WN 2141	WN 2142	WN 2143	WN 2147
			

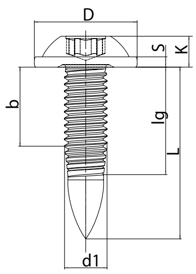
H-cross recess	Z-cross recess	TORX®	TORX plus® / AUTOSERT®
			

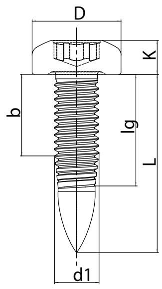
In case of manual assembly with TORX® it is recommended to use a TORXALIGN® bit, e.g. STICK FIT bits by TORX PLUS® drives.

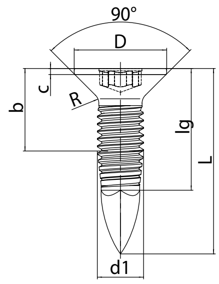
All cross recess and TORX® drives are also available as combi drives.

FDS®	Nominal-Ø			M 3	M 3,5	M 4	M 5	M 6
	External thread-Ø		d_1	3,0	3,5	4,0	5,0	6,0
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	t min.	1,07	1,33	1,98	2,24	2,84
			t max.	1,70	1,96	2,61	2,90	3,50
	Z-cross-recess	penetration depth	t min.	1,08	1,40	2,01	2,27	2,91
			t max.	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	t min.	1,70	1,74	2,04	2,77	3,03
			t max.	2,00	2,24	2,54	3,27	3,53
	Z-cross-recess	penetration depth	t min.	1,68	1,65	1,90	2,64	3,02
			t max.	1,93	2,11	2,36	3,10	3,48
	Cross size H/Z			1	2	2	2	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	t min.	1,50	1,40	1,90	2,10	2,80
			t max.	1,80	1,90	2,40	2,60	3,30
	Z-cross-recess	penetration depth	t min.	1,48	1,34	1,60	2,05	2,46
			t max.	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

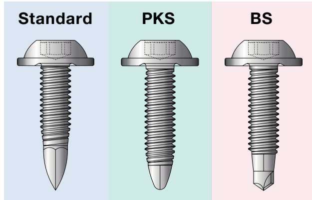
WN 2151	WN 2152	WN 2154







All WN-specifications according to types:



Ordering Example:

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

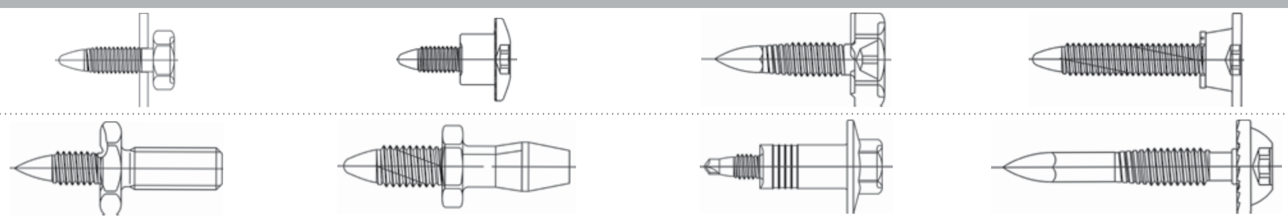
a) type Standard with Z-cross recess according to WN 2141: **FDS® screw M4 x 20 WN2141-Z**

b) type PKS with TORX® recess according to WN 2152: **FDS® screw M4 x 20 PKS WN2152**

c) type BS with hexagonal heat according to WN 2147: **FDS® screw M4 x 20 BS WN2147**

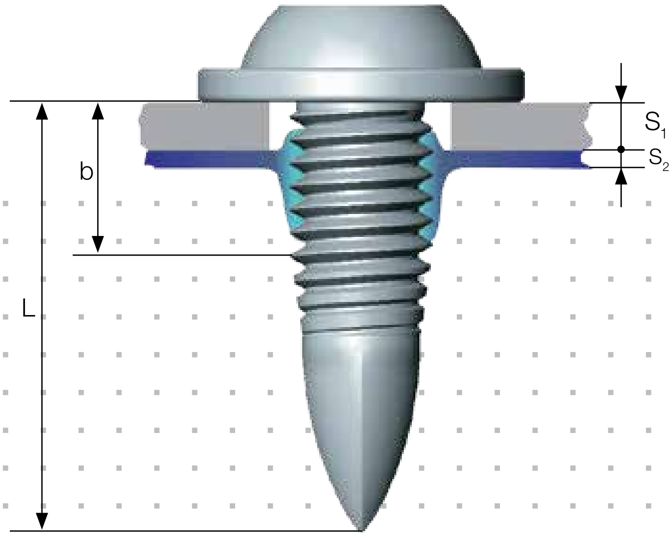
FDS®	Nominal-Ø		M 3	M 3,5	M 4	M 5	M 6
	External thread-Ø	d_1	3,0	3,5	4,0	5,0	6,0
WN 2151	Head-Ø	D	7,50	8,50	10,00	12,00	14,00
	Head height	K	2,70	2,90	3,60	3,90	4,80
	Washer thickness	s	0,70	0,80	1,00	1,20	1,40
	TORX®		T10	T15	T20	T25	T30
		$A_{max.}$	2,80	3,35	3,95	4,50	5,60
	Penetration depth	t min.	1,00	1,20	1,40	1,60	2,00
		t max.	1,30	1,50	1,80	2,00	2,40
WN 2152	Head-Ø	D	6,00	7,00	8,00	10,00	12,00
	Head height	K	2,70	2,90	3,60	3,90	4,80
	TORX®		T10	T15	T20	T25	T30
		$A_{max.}$	2,80	3,35	3,95	4,50	5,60
	Penetration depth	t min.	1,00	1,20	1,40	1,60	2,00
		t max.	1,30	1,50	1,80	2,00	2,40
WN 2154	Head-Ø	D	5,60	6,50	7,50	9,20	11,00
	Cyl. Head height	c_{max}	0,60	0,65	0,70	0,75	0,85
	TORX®		T10	T15	T20	T25	T30
		$A_{max.}$	2,80	3,35	3,95	4,50	5,60
	Penetration depth	t min.	0,75	0,85	1,10	1,15	1,40
		t max.	1,10	1,15	1,55	1,55	1,80

Special variations / Examples



Special variations are available.
Please contact the ATF application engineers to for assistance with your multifunctinal design.

Design Recommendations



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 depending on the part's thickness S_1 and the metal sheet thickness S_2.

It is given by:

$b = S_1 + 3 \times S_2$ without prepunching (type Standard)
$b = S_1 + 2 \times S_2$ with prepunching (type PKS and BS)

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

Example
S_1 = 4,50 mm, S_2 = 0,75 mm:

without prepunching
b = (4,50 + 3 x 0,75) mm = 6,75 mm

with prepunching
b = (4,50 + 2 x 0,75) mm = 6,00 mm

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.

Manufacturing range

FDS® screw	M3			M3,5			M4			M5			M6		
	Standard	PKS	BS	Standard	PKS	BS	Standard	PKS	BS	Standard	PKS	BS	Standard	PKS	BS
Length L [mm]	**Usable thread length b [mm]**														
9 + 0,8	2,40	4,70													
10 + 0,8	3,40	5,70		2,40	4,90	4,60									
12 + 0,8	5,40	7,70		4,40	6,90	6,60	3,10	5,70	5,40						
14 + 0,8	7,40	9,70		6,40	8,90	8,60	5,10	7,70	7,40	2,90	6,20	6,10			
16 + 0,8	9,40	11,70		8,40	10,90	10,60	7,10	9,70	9,40	4,90	8,20	8,10	2,90	6,60	5,90
18 + 0,8	11,40	13,90		10,40	12,90	12,60	9,10	11,70	11,40	6,90	10,20	10,10	4,90	8,60	7,90
20 + 0,8				12,40	14,90	14,60	11,10	13,70	13,40	8,90	12,20	12,10	6,90	10,60	9,90
25 + 0,8							16,10	18,70	18,40	13,90	17,20	17,10	11,90	15,60	14,90
30 + 0,8										18,90	22,20	22,10	16,90	20,60	19,90
35 + 1,0													21,90	25,60	24,90
40 + 1,0													26,90	30,60	29,90
45 + 1,0													31,90	35,60	34,90
50 + 10													36,90	40,60	39,90

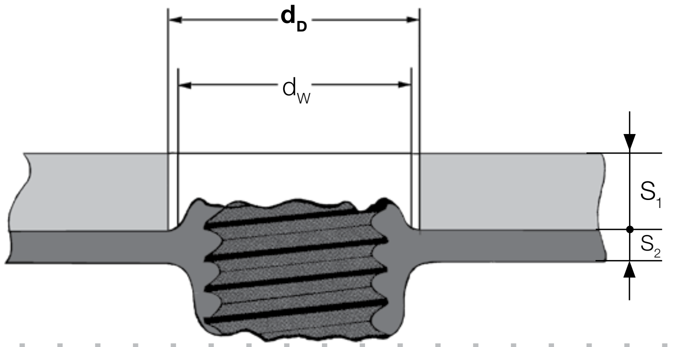
Special lengths upon request.

- - - - = minimum length for countersunk heads

Recommended clearance hole d_D [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.

FDS®	M3	M3,5	M4	M5	M6
d_D	3,6 - 4,0	4,3 - 4,8	5,1 - 5,7	6,7 - 7,4	8,2 - 9,1

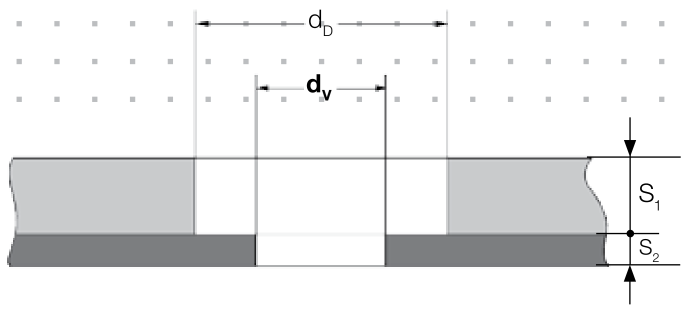


Clearance hole d_D for clamped material
d_W : bulge diameter
d_D : clearance hole

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.

FDS®		M3	M3,5	M4	M5	M6
sheet thickness S_2 [mm]	0,5	1,0 - 1,4	1,2 - 1,7	1,5 - 2,0	1,8 - 2,5	-
	0,63	1,2 - 1,6	1,4 - 1,8	1,6 - 2,2	1,8 - 2,5	2,0 - 3,0
	0,75	1,6 - 1,8	1,6 - 2,0	1,8 - 2,5	2,0 - 2,8	2,2 - 3,2
	0,88	1,8 - 2,2	1,8 - 2,3	2,0 - 2,6	2,2 - 3,0	2,5 - 3,5
	1,00	-	1,8 - 2,4	2,2 - 2,8	2,6 - 3,4	2,8 - 3,8
	1,25	-	-	2,4 - 3,0	3,0 - 3,8	3,4 - 4,5
	1,50	-	-	-	3,4 - 4,2	3,8 - 5,0
	>1,50	-	-	-	4,2 - 4,6	5,2 - 5,6



Pilot hole d_V for the installation part (type PKS)

d_V : pilot hole diameter
d_D : clearance hole

* 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)

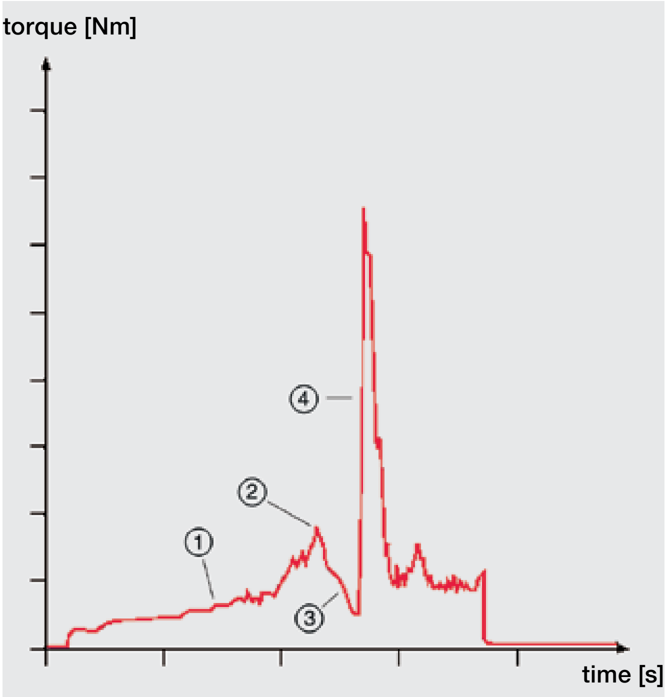
Note for manual assembly

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.

For more information about design or assembly recommendations please contact:
Brett Henry - Product Line Specialist / Light-weighting
phone 248-505-3056
e-mail: bhenry@atf-inc.com

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 necesarry 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.

Robot-aided fastening system by Weber Schraubautomaten

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.

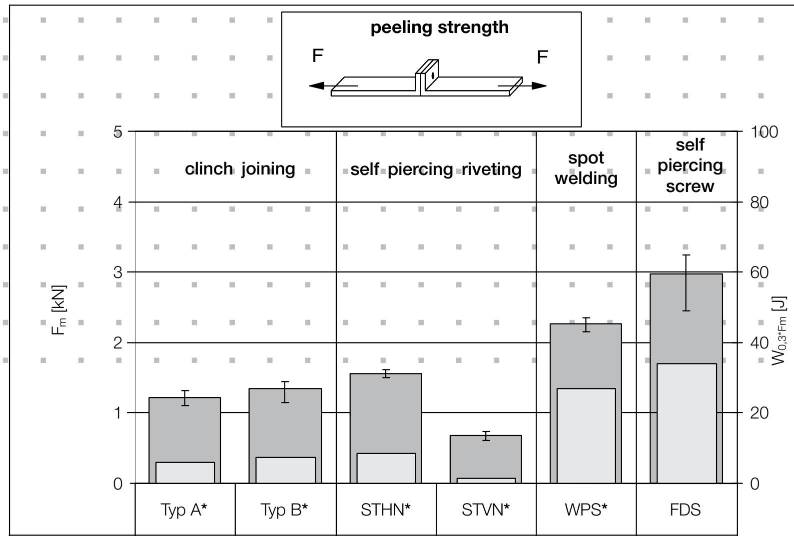
To determine the parameters assembly tests in our application technology laboratory can be carried out.

Properties in use

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.



	Typ A*	Typ B*	STHN*	STVN*	WPS*	FDS
Fm [kN]	1,21	1,35	1,56	0,68	2,27	2,98
W0,3Fmax [J]	5,86	7,35	8,58	1,29	26,94	33,92

* Hahn, O.; Schulte, A.: Ergebnisse aus P 283 "Eignung des Durchsetzfügens und des Stanznietens zum Fügen höherfester Stahlbleche", Studiengesellschaft Stahlanwendung e.V., 1995

material arrangement
ZStE 340; t=1,00 mm
ZStE 340; t=1,00 mm

no. of samples
7

audit procedure
peeling strength test

joining methods
clinch joining
typ A: round point Ø 8 mm (fixed dye)
typ B: round point Ø 8 mm (dye with sliding pieces)
self piercing riveting
STHN: semi tubular rivet Ø 5,3 mm
STVN: solid rivet Ø 4,0 mm
spot welding
WPS: lens Ø 5,2 mm
self piercing screw
FDS M5

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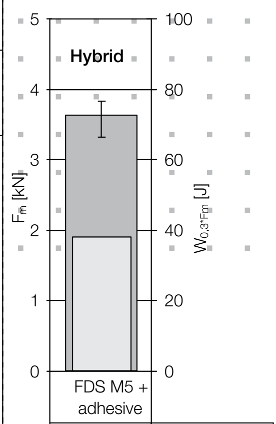
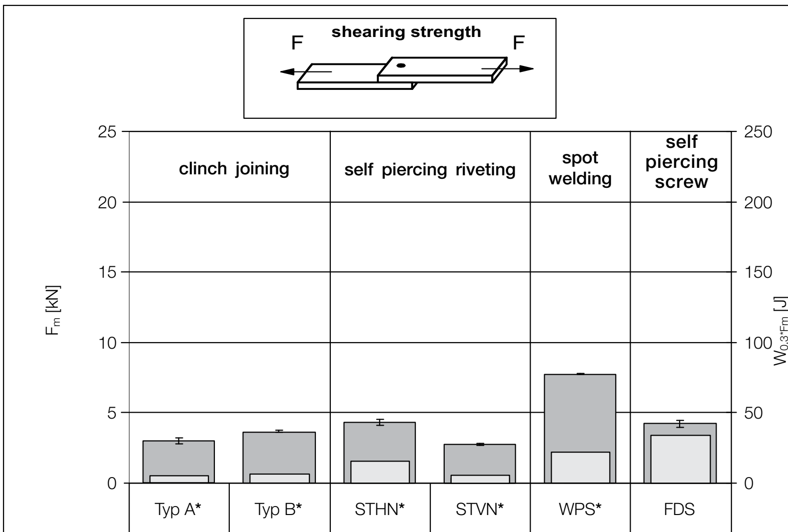


	FDS M5 + adhesive
Fm [kN]	3,63
W0,3Fmax [J]	37,87

peeling strength F_m and energy absorption $W_{0,3*Fm}$ of different joining methods in steel (ZStE 340)



	Typ A*	Typ B*	STHN*	STVN*	WPS*	FDS
Fm [kN]	2,96	3,64	4,29	2,75	7,74	4,23
W0,3Fmax [J]	4,61	6,23	15,41	5,72	22,23	33,69

* Hahn, O.; Schulte, A.: Ergebnisse aus P 283 "Eignung des Durchsetzfügens und des Stanznietens zum Fügen höherfester Stahlbleche", Studiengesellschaft Stahlanwendung e.V., 1995

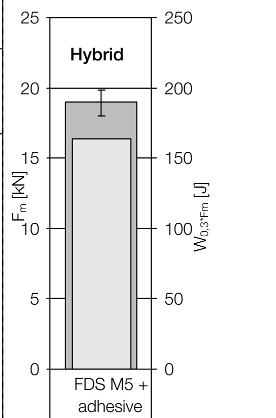
material arrangement
ZStE 340; t=1,00 mm
ZStE 340; t=1,00 mm

no. of samples
7

audit procedure
shearing strength test

joining methods
clinch joining
typ A: round point Ø 8 mm (fixed dye)
typ B: round point Ø 8 mm (dye with sliding pieces)
self piercing riveting
STHN: semi tubular rivet Ø 5,3 mm
STVN: solid rivet Ø 4,0 mm
spot welding
WPS: lens Ø 5,2 mm
self piercing screw
FDS M5

Universität Paderborn, LWF
Prof. O. Hahn, C. Bye



	FDS M5 + adhesive
Fm [kN]	18,96
W0,3Fmax [J]	163,78

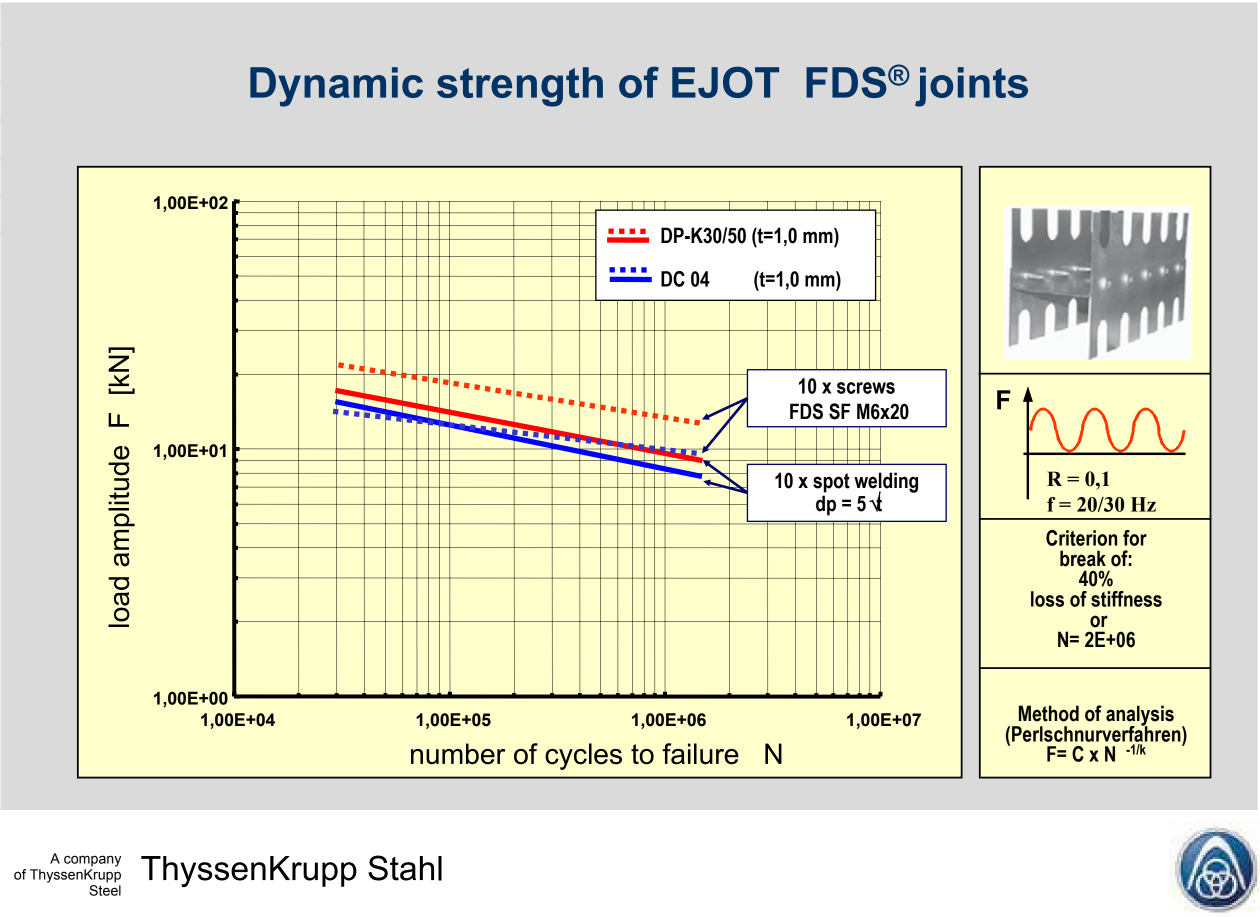
shearing strength F_m and energy absorption $W_{0,3*Fm}$ of different joining methods in steel (ZStE 340)

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.

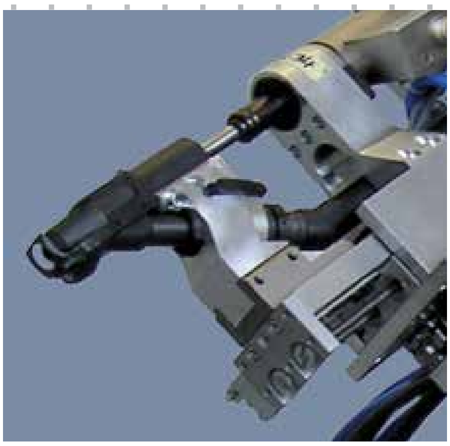


Influence of joining method and sheet steel grade on the fatigue strength

Function of joining without pilot and clearence hole

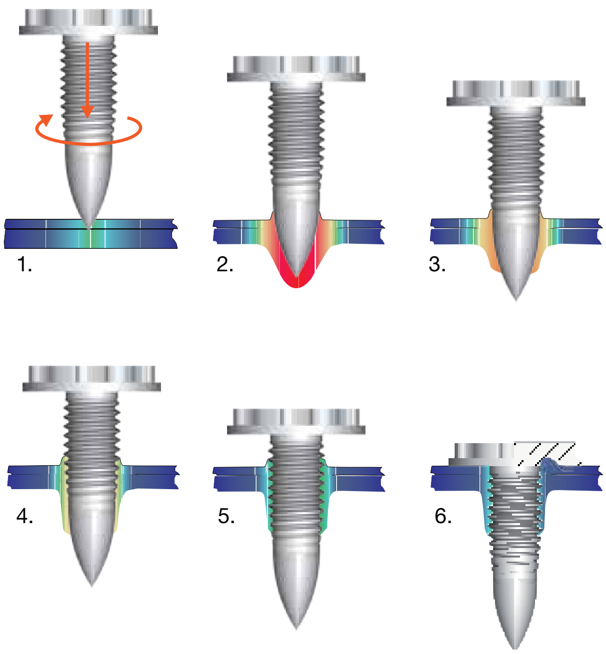
Application example: Aluminium sheet on extruded aluminium profile

Application example: Composite construction - plastic on aluminium profile



Retainer under the nozzle of the fastening system

(Source: Weber Schraubautomaten)



Process steps of the FDS® assembly without pilot hole

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


IN R 805

ATF, Inc.
3550 West Pratt Avenue
Lincolnwood, IL 60712
phone 847-677-1300
fax 847-677-9335
e-mail: quoting@atf-inc.com
internet: www.atf-inc.com

For addtional information please contact:
Brett Henry - Product Specialist / Light-weighting
248-505-3056
bhenry@atf-inc.com

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