

# **Thread Forming Screws for Plastics**

There are three primary methods of using threaded fasteners to blind-join components to plastic substrates: thread forming screws, thread cutting screws and metallic inserts with machine thread screws. The table below offers a proximal comparison of the techniques.

Fastener Type	Ease of Screw Removal and Reassembly	Use with Very Brittle Thermoset Plastics	Lowest Installed Cost	Most Resistant to Loosening	Least Plastic Installation Stress	Greatest Number of Options	Smallest Overall Footprint
Thread Forming Screw	**		***	***	*	**	***
Thread Cutting Screw		***	***	**	***	**	***
Insert w/ Machine Screw	***	***	*	*	**	***	*

This technical bulletin presents a comprehensive overview on the design, selection and installation of thread forming screws in plastics offered by PENCOM.

## **THREAD DESIGN**

Thermoplastics are polymers composed of long, random molecular chains with ductile behavior that promotes cold-forming and filling in around tapping screw threads. Unlike standard Type B thread forming screws with 60° thread flank angles, those designed specifically for plastics have more narrow and taller thread profiles with sharp 30° to 48° thread flank angles and wider thread spacings that reduce the amount of outward radial force (Fr) and take advantage of the plastics' ductile flowing behavior. This allows for reduced boss diameters and plastic damage, installation in a wide variety of plastic strengths, lower installation drive torque and more resistance to stripping and pull out. Thermosetting plastics are less ductile and too stiff for thread forming screws. In those applications thread cutting screws, which are tapping screws with special features on the lead threads that remove material during installation, should be considered.





## **INSTALLATION TORQUE**

One of the most common questions regarding thread forming screw installation is "what installation torque should be used?" Unfortunately unlike machine screws, there are no published calculations for determining thread forming screw installation torque and can be simultaneously affected by the following each having a multitude of possibilities.

Hole diameter and draft	Number of engaged threads	Boss wall thickness
Screw finish	Installation rpm	Thread shape and spacing
Plastic temperature	Plastic material type	Desired clamp load

Therefore, the only way to determine a suitable installation torque is through testing in conditions as close as possible to the actual application. The adjacent graph illustrates how thread forming screws in plastic respond to applied torque. From the points 1 to 2, torque is applied to form the threads. As the number of engaged threads increases so too does the required torque to overcome the additional friction. At point 2 the screw head is seated and any further torque results in compressive loading of plastic against the screw threads and is referred to as stripping torque. At point 3 the fastener fails due to several different possible modes such as thread stripping, fastener failure or boss collapse.



A potential installation torque spec might be somewhere in the lower 1/3 to 1/2 of the stripping range (2-3) with a tolerance of 5-10% depending on the accuracy of the installation tool at the specified rpm. As clamping load increases material relaxation (creep) and potential for stress cracking rise as well. Therefore, PENCOM strongly encourages using the minimum necessary tightening torque rather than the maximum that can be achieved before failure.

## **DRIVER SPEED**

Friction between the screw threads and boss wall generates heat during installation. High driver rpm can cause excessive heat that may melt and damage the plastic creating a weak joint and increasing the likelihood of stripping failure during installation. Because of the wide thread spacing associated with thread forming screws, fewer rotations are needed for installation so faster rpm's don't neccessarily translate to reduced assembly times. As a guideline 300-500 rpm generally results in proper installation while maintaining high productivity.

#### SELECTION

PENCOM offers four types of thread forming screws for plastics,

#### HILO

PF

Feature a unique twin thread profile with different thread flank angles and diameters.

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Designed with a distinctive thread profile and root for use in a wide variety of thermoplastic materials.

#### PLAST45

Tri-Nodular<sup>™</sup> body cross-section resists loosening and extra wide thread spacing offers excellent performance in hard plastics.

#### PLAST48-2

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Similar body cross-section to the PLAST45 but with twin-lead threads for faster engagement and easier installation tool adjustments.

The table below offers thread type guidance for some common thermoplastic materials. These are approximate recommendations only as there are numerous factors affecting fastener performance.

	Thermoplastic	Flexural Modulus (KSI)	Thread Type	
Very	Polyethylene (PE)	150 200	HILO	
Soft	Polypropylene (PP)	150-200	PF	
	Acrylonitrile Butadiene Styrene (ABS) 0-20% Glass Filled			
	Polyamide 66 (PA 66)			
	Polycarbonate (PC)		HILO PF PLAST48-2	
Soft	Acetal (POM)	340-550		
	Polypropylene (PP) 40% Talc-filled			
	Polyphenylene Sulfide (PPS)			
	Polystyrene (PS)			
	Acrylonitrile Butadiene Styrene (ABS) 20% Glass Filled			
Medium	Polyamide 66 (PA 66) 12% Glass Filled	650-850	PF PLAST48-2	
	Polycarbonate (PC) 20% Glass Filled			
	Acrylonitrile Butadiene Styrene/Polycarbonate (ABS/PC Blend)			
Llord	Polyamide 66 (PA 66) 30% Glass Filled	1 100 1 400	PF	
naru	Polybutylene Terephthalate (PBT) 30% Glass Filled	1,100-1,400	PLAST45	
	Polycarbonate (PC) 30% Glass Filled			

Ref.: Acument Global Technologies

When using thermosetting plastics and those with flexural moduli greater than 1,400 ksi, thread cutting screws should be considered instead. They remove material when being installed thus reducing stress in very brittle plastics. However, they can be difficult to remove and re-install, and may not have the same loosening resistance.

# **OPTIONS**

In addition to a variety of thread sizes, lengths, head types, drives, materials and finishes, PENCOM also offers custom designs. Contact a company representative for more information.



PENCOM's HILO screws utilize a unique twin thread profile design with different thread flank angles and diameters. The high thread has a 30° flank angle that reduces radial boss stress and improves thread engagement in softer thermoplastics.



	Thread Size	High Thread Diameter D1	Low Thread Diameter D2 (Ref.)	Minor Diameter R
	2-32	.084090	.069	.050058
	3-28	.095105	.078	.057065
	4-24	.105115	.086	.061070
	5-20	.119125	.100	.073082
Ì	6-19	.135145	.108	.080090
≤	7-19	.148158	.130	.089100
	8-18	.160170	.130	.095105
	9-18	.175185	.145	.097108
	10-16	.185195	.145	.099110
	12-16	.210220	.167	.125137
	1/4-15	.250260	.200	.161175
	5/16-14	.307317	.250	.200212

# THREAD DIMENSIONS

	Thread	High Thread Diameter	Low Thread	Minor Diameter	
	Size	D1	D2 (Ref.)	R	
	M2.2 x 0.79	2.13-2.29	1.75	1.27-1.47	
	M2.5 x 0.91	2.41-2.67	1.98	1.45-1.65	
	M2.9 x 1.06	2.66-2.92	2.18	1.55-1.78	
IC	M3.2 x 1.27	3.02-3.18	2.54	1.85-2.08	
ETR	M3.5 x 1.34	3.43-3.69	2.74	2.03-2.29	
M	M3.8 x 1.34	3.76-4.02	3.30	2.26-2.54	
	M4.2 x 1.41	4.06-4.32	3.30	2.41-2.67	
	M4.5 x 1.41	4.44-4.70	3.68	2.46-2.74	
	M4.8 x 1.59	4.70-4.96	3.68	2.51-2.79	
	M5.5 x 1.59	5.33-5.59	4.24	3.18-3.48	
	M6.3 x 1.69	6.35-6.61	5.08	4.09-4.45	
	M8 x 1.81	7.79-8.05	6.35	5.08-5.38	

All dimensions in inches

All dimensions in millimeters

## **BOSS DIMENSIONS**



			Hole Dia	meter, H			
	Thread	Boss	Plastic Flexu	Iral Modulus	Counterbore	Counterbore Depth T	Thread Engagement
	Size	B	< 200 KSI	200-400 KSI	N		Length L
	2-32	.174261	.0670	.0700	.095	.031063	.261
	3-28	.200300	.0730	.0781	.108	.036071	.300
	4-24	.220330	.0810	.0860	.118	.042083	.330
ς Σ	5-20	.244366	.0935	.0995	.130	.050100	.366
=	6-19	.280420	.1015	.1100	.148	.053105	.420
	7-19	.306459	.1200	.1250	.161	.053105	.459
	8-18	.330495	.1200	.1285	.173	.056111	.495
	9-18	.360540	.1290	.1380	.188	.056111	.540
	10-16	.380570	.1360	.1440	.198	.063125	.570
	12-16	.430645	.1570	.1660	.223	.063125	.645
	1/4-15	.510765	.1890	.2010	.263	.067133	.765
	5/16-14	.624936	.2380	.2500	.320	.071143	.936

(1) Dimensions are for reference only and may be affected by several variables. PENCOM strongly encourages testing in the application.

	All dimensions in millimeters										
			Hole Dia	meter, H							
	Thread	Boss	Plastic Flexu	ural Modulus	Counterbore	Counterbore	Thread Engagement				
	Size	B	< 1,380 Mpa	1,380- 2,760 Mpa	N	T T	Length L				
	M2.2 x 0.79	4.42-6.63	1.702	1.778	2.41	0.79-1.58	6.63				
	M2.5 x 0.91	5.08-7.62	1.854	1.984	2.74	0.91-1.82	7.62				
2	M2.9 x 1.06	5.59-8.38	2.057	2.184	2.99	1.06-2.12	8.38				
H H	M3.2 x 1.27	6.20-9.30	2.375	2.527	3.30	1.27-2.54	9.30				
Ξ	M3.5 x 1.34	7.11-10.67	2.578	2.794	3.76	1.34-2.68	10.67				
	M3.8 x 1.34	7.77-11.66	3.048	3.175	4.09	1.34-2.68	11.66				
	M4.2 x 1.41	8.38-12.57	3.048	3.264	4.39	1.41-2.82	12.57				
	M4.5 x 1.41	9.14-13.72	3.277	3.505	4.77	1.41-2.82	13.72				
	M4.8 x 1.59	9.65-14.48	3.454	3.658	5.03	1.59-3.18	14.48				
	M5.5 x 1.59	10.92-16.38	3.988	4.216	5.66	1.59-3.18	16.38				
	M6.3 x 1.69	12.95-19.43	4.801	5.105	6.68	1.69-3.38	19.43				
	M8 x 1.81	15.85-23.77	6.045	6.350	8.12	1.81-3.62	23.77				

(1) Dimensions are for reference only and may be affected by several variables. PENCOM strongly encourages testing in the application.

PENCOM's PF screws have a unique thread forming design conceived expressly for use in a wide variety of thermoplastic materials. The distinctive thread profile allows reduced boss wall thickness, maintains clamp load and resists loosening during vibration, reduces drive torque while increasing stripping torque, and reduces hoop stresses.



## **THREAD DIMENSIONS**

Thread Size	K15	K18	K20	K22	K25	K30	K35	K40	K50	K60	K70	K80
D	1.5	1.8	2.0	2.2	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0
R	0.89	1.04	1.15	1.25	1.40	1.66	1.91	2.17	2.68	3.19	3.70	4.21

## **BOSS DIMENSIONS**



(1° Max. Hole Draft Angle)

Material	Boss Diameter B	Hole Diameter H	Min. Thread Engagement Length L
Acrylonitrile Butadiene Styrene (ABS)	2.00 x D	.80 x D	2.00 x D
Acrylonitrile Butadiene Styrene (ABS) / Polycarbonate (PC) Blend	2.00 x D	.80 x D	2.00 x D
Acrylonitrile Styrene Acrylate (ASA)	2.00 x D	.78 x D	2.00 x D
Nylon 4/6	1.85 x D	.73 x D	1.80 x D
Nylon 4/6 30% Glass Filled	1.85 x D	.78 x D	1.80 x D
Nylon 6	1.85 x D	.75 x D	1.70 x D
Nylon 6 30% Glass Filled	2.00 x D	.80 x D	1.90 x D
Nylon 6/6	1.85 x D	.75 x D	1.70 x D
Nylon 6/6 30% Glass Filled	2.00 x D	.82 x D	1.80 x D
Polyamide (PA) 15% Glass Filled	2.00 x D	.82 x D	2.00 x D
Polybutylene Terephthalate (PBT)	1.85 x D	.75 x D	1.70 x D
Polybutylene Terephthalate (PBT) 30% Glass Filled	1.80 x D	.80 x D	1.70 x D
Polycarbonate (PC)	2.50 x D	.85 x D	2.20 x D
Polycarbonate (PC) 30% Glass Filled	2.20 x D	.85 x D	2.00 x D
Polyethylene (PE)	2.00 x D	.70 x D	2.00 x D
Rigid Polyethylene (PE)	1.80 x D	.75 x D	1.80 x D
Polyethylene Terephthalate (PET)	1.85 x D	.75 x D	1.70 x D
Polyethylene Terephthalate (PET) 30% Glass Filled	1.80 x D	.80 x D	1.70 x D
Polyoxymethylene (POM/Acetal)	1.95 x D	.75 x D	2.00 x D
Polymethyl Methacrylate (PMMA)	2.00 x D	.85 x D	2.00 x D
Polypropylene (PP)	2.00 x D	.70 x D	2.00 x D
Polypropylene (PP) 20% Talc Filled	2.00 x D	.72 x D	2.00 x D
Polyphenylene Oxide (PPO/Noryl)	2.50 x D	.85 x D	2.20 x D
Polystyrene (PS)	2.00 x D	.80 x D	2.00 x D
Rigid Polyvinyl Chloride (PVC)	2.00 x D	.80 x D	2.00 x D
Styrene Acrylonitrile (SAN)	2.00 x D	.77 x D	1.90 x D

Dimensions are for reference only and may be affected by several variables. PENCOM strongly encourages testing in the application.
Ref.: ATF, Inc.

PLAST45 screw threads have a sharp 45° flank angle and extra wide spacing to reduce and disperse stress in a plastic member while maintaining high stripping resistance. The body cross-section uses a Tri-Nodular<sup>™</sup> design that allows plastic material to fill in behind the thread node relief areas creating resistance to vibrational loosening. These screws are particularly suited for hard plastics.



#### **THREAD DIMENSIONS**

	Thread Size	Theoretical Diameter C	Cross-Section Depth D
	2-19	.08350875	.08050845
	3-18	.09701010	.09400980
	4-17	.10951145	.10601110
-	5-15	.12251275	.11851235
L C L	6-13	.13601410	.13201370
≤	7-12	.14801530	.14351485
	8-11	.16101670	.15601620
	9-10	.17301790	.16801740
	10-9	.18801940	.18301890
	12-9	.21402200	.20852145
	1/4-8	.24702530	.24102470
	5/16-8	.30803160	.30103090

	Thread Size	Theoretical Diameter C	Cross-Section Depth D	
	M1.6 x 0.6	1.61-1.69	1.54-1.61	
	M2 x 1.35	1.92-2.04	1.87-1.99	
ပ	M2.5 x 1.4	2.41-2.53	2.37-2.49	
TRI	M3 x 1.5	2.92-3.04	2.87-2.99	
ЧE	M3.5 x 1.65	3.42-3.54	3.34-3.46	
	M4 x 1.75	3.89-4.04	3.79-3.94	
	M4.5 x 2	4.39-4.54	4.28-4.43	
	M5 x 2.2	4.89-5.04	4.79-4.94	
	M5 x 2.3	4.89-5.04	4.79-4.94	
	M6 x 2.5	5.89-6.04	5.78-5.93	
	M8 x 3	7.86-8.04	7.71-7.89	
		All dimen	sions in millimeters	

All dimensions in inches

## **BOSS DIMENSIONS**



TB-TF SCREWS FOR PLASTICS 01/17/23

	Thread Size	Boss Diameter B	Hole Diameter H	Counterbore Diameter N	Counterbore Depth T	Thread Engagement Length L
	2-19	.214257	.065073	.094	.013026	.171257
	3-18	.248297	.076084	.107	.014028	.198297
	4-17	.280336	.087096	.120	.015029	.224336
Т	5-15	.313375	.099108	.133	.017033	.250375
NC	6-13	.346416	.102114	.147	.019038	.277416
	7-12	.376452	.114127	.159	.021042	.301452
	8-11	.410492	.126139	.172	.023045	.328492
	9-10	.440528	.135149	.184	.025050	.352528
	10-9	.478573	.150165	.199	.028056	.382573
	12-9	.543651	.170186	.225	.028056	.434651
	1/4-8	.625750	.198216	.258	.031063	.500750
	5/16-8	.780936	.255275	.320	.031063	.624936

Dimensions are for reference only and may be affected by several variables. PENCOM strongly encourages testing in the application.
Ref.: Research Engineering and Manufacturing, Inc.

All dimensions in millimeter							
METRIC	Thread Size	Boss Diameter B	Hole Diameter H	Counterbore Diameter N	Counterbore Depth T	Thread Engagement Length L	
	M1.6 x 0.6	4.13-4.95	1.09-1.29	1.85	0.15-0.30	3.30-4.95	
	M2 x 1.35	4.95-5.94	1.40-1.60	2.18	0.34-0.68	3.96-5.94	
	M2.5 x 1.4	6.18-7.41	1.85-2.05	2.67	0.35-0.70	4.94-7.41	
	M3 x 1.5	7.45-8.94	2.30-2.50	3.18	0.38-0.75	5.96-8.94	
	M3.5 x 1.65	8.70-10.44	2.75-3.00	3.68	0.41-0.83	6.96-10.44	
	M4 x 1.75	9.91-11.90	3.20-3.45	4.17	0.44-0.88	7.93-11.90	
	M4.5 x 2	11.16-13.40	3.60-3.90	4.67	0.50-1.00	8.93-13.40	
	M5 x 2.2	12.41-14.90	3.70-4.10	5.17	0.55-1.10	9.93-14.90	
	M5 x 2.3	12.41-14.90	3.70-4.10	5.17	0.58-1.15	9.93-14.90	
	M6 x 2.5	14.91-17.90	4.70-5.10	6.17	0.63-1.25	11.93-17.90	
	M8 x 3	19.88-23.85	6.50-7.10	8.15	0.75-1.50	15.90-23.85	

(1) Dimensions are for reference only and may be affected by several variables. PENCOM strongly encourages testing in the application.(2) Ref.: Research Engineering and Manufacturing, Inc.

PLAST48-2 screws have twin lead threads with 48° flank angles. The sharp thread profile reduces plastic boss stress while providing excellent holding strength. A steeper thread helix angle due to the twin lead design allows for faster engagement and provides for a greater difference between failure and thread forming torques which can simplify drive tool adjustments. The body cross-section uses a Tri-Nodular<sup>™</sup> design that allows plastic material to fill in behind the thread node relief areas creating resistance to vibrational loosening. These screws are suitable for use in a wide variety of soft to moderately hard plastics.



#### **THREAD DIMENSIONS**

	Thread Size	Theoretical Diameter C	Cross-Section Depth D	
	00-51	.04660496	.04450475	
	0-42	.06350665	.06050635	
	1-32	.078081	.075078	
	2-28	.086092	.083089	
	3-24	.104110	.100106	
т	4-20	.121127	.117123	
NC	6-19	.141147	.137143	
-	7-18	.160166	.154160	
	8-16	.179185	.173179	
	9-15	.193199	.187193	
	10-14	.206212	.202208	
	12-11	.229235	.224230	
	12-14	.226232	.220226	
	1/4-10	.270276	.262268	
	5/16-9	.335345	.325335	

	Thread Size	Theoretical Diameter C	Cross-Section Depth D	
	M1.12 x 0.50	1.18-1.26	1.13-1.21	
	M1.59 x 0.60	1.61-1.69	1.54-1.61	
	M1.91 x 0.79	1.98-2.06	1.91-1.98	
	M2.26 x 0.91	2.18-2.34	2.11-2.26	
	M2.63 x 1.06	2.64-2.79	2.54-2.69	
SIC	M3.12 x 1.27	3.07-3.23	2.97-3.12	
Ë.	M3.63 x 1.34	3.58-3.73	3.48-3.63	
Σ	M4.06 x 1.41	4.03-4.22	3.91-4.06	
	M4.55 x 1.59	4.55-4.70	4.39-4.55	
	M4.90 x 1.69	4.90-5.05	4.75-4.90	
	M5.28 x 1.81	5.23-5.38	5.13-5.28	
	M5.74 x 1.81	5.74-5.89	5.59-5.74	
	M5.74 x 2.31	5.74-5.89	5.59-5.74	
	M6.81 x 2.54	6.86-7.01	6.65-6.81	
	M8.51 x 2.82	8.51-8.76	8.26-8.51	

All dimensions in inches

#### **BOSS DIMENSIONS**



All dimensions in millimeters

	Thread Size	Boss Diameter B	Hole Diameter H		Counterbore	Counterbore	Thread
			Soft Ductile Materials	Brittle Materials	Diameter N	Depth T	Engagement Length L
	00-51	.120144	.043	.046	.056	.005010	.096144
	0-42	.163195	.056	.060	.073	.006012	.130195
	1-32	.199239	.067	.072	.088	.008016	.159239
-	2-28	.223267	.076	.080	.097	.009018	.178267
INCF	3-24	.268321	.088	.094	.115	.010021	.214321
	4-20	.310372	.100	.106	.132	.013025	.248372
	6-19	.360432	.122	.128	.152	.013026	.288432
	7-18	.408489	.134	.142	.171	.014028	.326489
	8-16	.455546	.149	.158	.190	.016031	.364546
	9-15	.490588	.162	.172	.204	.017033	.392588
	10-14	.523627	.175	.185	.217	.018036	.418627
	12-11	.580696	.195	.206	.240	.023045	.464696
	12-14	.573687	.195	.205	.237	.018036	.458687
	1/4-10	.683819	.224	.240	.281	.025050	.546819
	5/16-9	.850-1.02	.286	.303	.348	.028056	.680-1.02

Dimensions are for reference only and may be affected by several variables. PENCOM strongly encourages testing in the application.
Ref.: Research Engineering and Manufacturing, Inc.

	All dimensions in millimeter						
	Thread Size	Boss Diameter B	Hole Diameter H		Counterbore	Counterbore	Thread
			Soft Ductile Materials	Brittle Materials	Diameter N	Depth T	Length L
	M1.12 x 0.50	3.05-3.67	1.092	1.168	1.42	0.13-0.25	2.44-3.67
	M1.59 x 0.60	4.13-4.95	1.422	1.524	1.85	0.15-0.30	3.30-4.95
	M1.91 x 0.79	5.05-6.06	1.702	1.829	2.22	0.20-0.40	4.04-6.06
	M2.26 x 0.91	5.65-6.78	1.930	2.032	2.46	0.23-0.46	4.52-6.78
METRIC	M2.63 x 1.06	6.79-8.15	2.235	2.388	2.92	0.27-0.53	5.44-8.15
	M3.12 x 1.27	7.87-9.45	2.540	2.692	3.35	0.32-0.64	6.30-9.45
	M3.63 x 1.34	9.14-10.97	3.099	3.251	3.86	0.34-0.67	7.32-10.97
	M4.06 x 1.41	10.35-12.42	3.404	3.607	4.34	0.35-0.71	8.28-12.42
	M4.55 x 1.59	11.56-13.87	3.785	4.013	4.82	0.40-0.80	9.25-13.87
	M4.90 x 1.69	12.45-14.94	4.115	4.369	5.18	0.42-0.85	9.96-14.94
	M5.28 x 1.81	13.27-15.93	4.445	4.699	5.51	0.45-0.91	10.62-15.93
	M5.74 x 1.81	14.73-17.68	4.953	5.232	6.09	0.45-0.91	11.79-17.68
	M5.74 X 2.31	14.54-17.45	4.953	5.207	6.02	0.58-1.16	11.63-17.45
	M6.81 X 2.54	17.34-20.80	5.690	6.096	7.13	0.64-1.27	13.87-20.80
	M8.51 X 2.82	21.59-25.91	7.264	7.696	8.84	0.71-1.41	17.27-25.91

Dimensions are for reference only and may be affected by several variables. PENCOM strongly encourages testing in the application.
Ref.: Research Engineering and Manufacturing, Inc.