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Introduction

Hornbeam™ T-nuts enable heavy-duty, adjustable fixturing for woodworkers, using special T-slots milled directly into wooden jigs, fixtures, and worktops. No metal T-track is required. T-slots are easily milled with a Hornbeam router bit, and T-slot intersections are automatically created anywhere that two slots cross.



A Hornbeam™ T-nut and T-slot

Hornbeam T-nuts are available with either 1/4"-20 or M6-1 female threads. M6-1 T-nuts are primarily intended for use with EdgeHugger® clamps; see the EdgeHugger® instructions for details. For imperial-thread fixturing, ToolQuest offers a range of 1/4"-20 fasteners that are ideal for implementing standard configurations. Hornbeam system components covered in this document include:

Part Number	Component Description
FS0106-0.250	Hornbeam T-nut, 1/4"-20
RB0141	Hornbeam Pro T-slot router bit
FS0110-1.125	Load-distribution washer, 1-1/8" OD x 1/8" thick, stainless steel
FS0111-x.xxx	Button-head screw, 1/4"-20, x.xxx" long, stainless steel
FS0112	Clamp-base washer, 2-3/16" OD x 0.060" thick, stainless steel

Part Number	Component Description
FS0113-x.xxx	Threaded stud, 1/4"-20, x.xxx" long
FS0114-1.250	Ergonomic clamp knob, 1/4"-20 male, 1.58" OD, 1.25" long stud
FS0115	Ergonomic clamp knob, 1/4"-20 female, 1.58" OD
FS0116-1/32	Hornbeam T-slot washer, 15/32" OD, 1/32" thick, stainless steel
FS0116-1/16	Hornbeam T-slot washer, 15/32" OD, 1/16" thick, stainless steel
FS0117	Hex jam nut, 1/4"-20, 5/32" thick, 18-8 stainless steel
FS0118-0.500	Hornbeam alignment pin, 3/32" OD, 0.5" long, stainless steel
FS0120-0.625	Flat washer for 1/4" screws, 5/8" OD, stainless steel

Note: Parts with "x.xxx" in the part number are available in multiple part lengths.

Theory of operation

Ordinary T-slot fasteners are designed to be used in metal T-track. When used in wooden T-slots, their small heads will crush wood-based materials long before the fastener reaches its design load. As for dovetail nuts, their steep wedge shape can jam the nut and/or distort the fixture under even modest clamping forces.

The clamping surfaces of Hornbeam™ T-nuts are three to ten times larger than those of conventional T-track fasteners, which greatly reduces the pressure on the fixture material. To further improve available clamping force, the clamping surfaces of Hornbeam T-nuts are designed with an 18° taper angle. This increases the strength of both the T-slots and the T-nuts without increasing T-slot depth, and without causing wedging or fixture distortion.

For T-slots milled in typical hardwoods, Hornbeam T-nuts can safely be used at their full rated working load of 500 lb. Even in softwoods, T-nut loads of several hundred pounds can be used without crushing the slot.

CAUTION: Hornbeam T-nuts are designed for clamping in one direction only. Do not apply reverse screw loads that could extract the brass threaded insert from the bottom of the T-nut body.

Clamping configurations

Fixed-height clamping

Either screws or male clamping knobs may be used to securely fasten fixed-height components anywhere along the length of a T-slot. Each fastener type has certain advantages.

- Clamp knobs provide tool-free operation, which can be desirable for frequently adjusted components.
- Screw heads have a lower profile. In fact, they can typically be recessed completely into the clamped component, if desired. Screws are also more economical, enable higher clamping forces, and are available in a greater selection of standard lengths.



A fixed-height clamping assembly, with a male clamp knob

When clamping a wooden fixture component, use a load-distribution washer beneath the clamp screw or knob. A washer of at least 7/8" in diameter is required to equal the clamping-surface area of a Hornbeam T-nut. Typical fender washers are too thin for the job, and will deform into a cone shape under high clamping forces. ToolQuest's FS0110-1.125 load-distribution washers are 1-1/8" in diameter and a full 1/8" thick, providing maximum protection to wooden fixture surfaces.

Threaded posts

Some fixtures, most notably pivot-style hold-down clamps, require an adjustable fastener length in order to accommodate a range of workpiece thicknesses. A Hornbeam T-nut plus a threaded stud creates a threaded post that is ideal for these applications.

Freely sliding posts

To configure a freely-sliding threaded post, thread a jam nut onto one end of the threaded stud, add a Hornbeam T-slot washer, and then thread that same end of the stud into a Hornbeam T-nut. A Hornbeam T-slot serves as a handy “wrench” for holding the T-nut while tightening the jam nut, and also serves as a maximum-depth gauge for the threaded stud. Alternatively, the threaded stud may be permanently assembled to the T-nut by applying a thread-locking adhesive.



A freely sliding threaded-post assembly

Fixed mounting posts

To configure a heavy-duty fixed mounting post for pivot clamps, thread a jam nut onto one end of the threaded stud, add a 2-3/16" diameter clamp-base washer, and then thread that same end of the stud into the Hornbeam T-nut. Slide the assembly to any desired position along a T-slot, and then tighten the jam nut to lock the post rigidly into position.



A fixed threaded-post assembly

A female clamp knob is ideal for actuating hold-down clamps, but a hex nut and washer can also be used. Under heavy clamping loads, the clamp-base washer prevents the heel of the pivot clamp from denting the fixture base.



A pivot clamp with a 2-1/2" threaded post

For taller workpieces, some hold-down clamps may be reversed and used with a 4" threaded stud. In this configuration, replace the 2-3/16" diameter clamp-base washer with a 1-1/8" load distribution washer. Due to the shorter reach of the reversed pivot clamp, a clamp-base washer may interfere with the workpiece.



A pivot clamp with a 4" threaded post

Headed-fastener lengths

Headed fasteners such as screws and male clamp knobs are typically used for fixed-height clamping. For full-load capability, there must be a minimum of 4 fastener threads engaged in the Hornbeam T-nut, which establishes a minimum length for the fastener. The fastener must also not thread completely through the nut and hit the bottom of the T-slot, which establishes a maximum length of fastener. A "suitable fastener length" may be anywhere between the minimum and maximum lengths.

Typical applications

The following table provides suitable fastener lengths for typical applications, when using a 1/8" thick load-distribution washer. Fastener lengths are measured from the underside of the head.

If fastener lengths on 1/8" intervals are not readily available, simply choose the next-longer 1/4"-interval fastener. Then use an extra 1/8" thick washer beneath the fastener head to compensate.

Suitable Fastener Lengths (in.)		T-slot depth (in.)		
		0.438	0.500	0.625
Fixture Thickness (in.)	0.000	0.500	0.500	0.625
	0.125	0.625	0.625	0.750
	0.250	0.750	0.750	0.875
	0.375	0.875	0.875	1.000
	0.500	1.000	1.000	1.125
	0.625	1.125	1.125	1.250
	0.750	1.250	1.250	1.375
	0.875	1.375	1.375	1.500
	1.000	1.500	1.500	1.625

Special applications

For special applications not addressed in the fastener-length chart, use the procedure below to determine a suitable fastener length.

Step 1: Determine the maximum fastener length:

- Option 1: Measure it. Measure the distance from the top of the load-distribution washer to the bottom of the T-slot, and subtract 1/32" (0.031") for T-slot bottom clearance.
- Option 2: Calculate it. Add the load-distribution washer thickness, the mounted-component thickness (less any counterbore depth), and the T-slot depth. Then subtract 1/32" (0.031") for slot bottom clearance.

Step 2: Determine the minimum fastener length:

- Subtract 1/8" (0.125") from the maximum fastener length.

Step 3: Select your fastener:

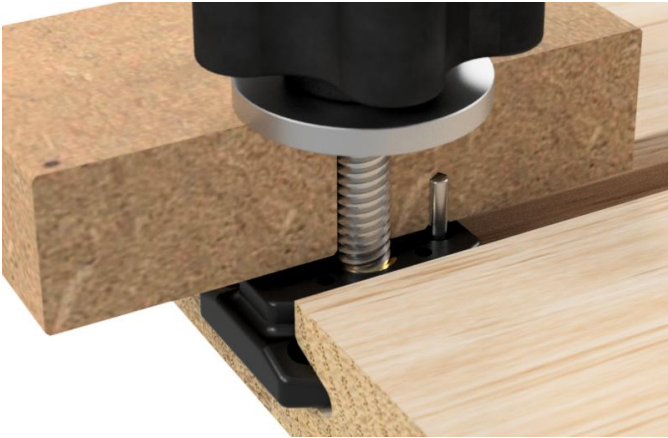
- Option 1: Round the maximum fastener length down to the nearest 1/8", and use a standard fastener.
- Option 2: Counterbore the screw hole to fit an available fastener length.
- Option 3: Use a longer fastener, but add washers beneath the fastener head to compensate.
- Option 4: Cut or grind a longer fastener to length.

Hornbeam alignment pins

Overview

Removable fixture components that are mounted with ordinary T-nuts or T-bolts can be inconvenient to install, especially when the component blocks your view of the T-slot. Conventional T-slot fasteners are free to rotate, so you must manually rotate each one into alignment with the T-slot before it can slide in.

Hornbeam T-nuts are designed to eliminate that hassle, by simply mounting an alignment pin on the fixture component. That alignment pin then mates with a clearance hole in the T-nut. With the alignment pin installed, the nut stays oriented in the proper direction, which greatly speeds fixture assembly.



A cutaway view showing a T-nut alignment pin

Installing alignment pins

Step 1: Insert a threaded fastener through the fixture component, and thread on a Hornbeam T-nut such that the bottom of the nut is against the component. (The alignment-pin clearance holes are slightly tapered, so this offers the most accurate alignment-pin location.)

Step 2: Align the T-nut to the fixture component, and then gently clamp it in place with the threaded fastener. *Do not over-torque the fastener, as this could extract the threaded insert from the bottom of the T-nut.*

Step 3: Drill a 3/32" diameter pin-mounting hole 1/4" deep into the fixture component.

- Option 1: Place a 3/32" transfer punch through one of the T-nut's alignment-pin holes, and tap it with a small hammer to mark the hole location. Then remove the nut, and drill the pin-mounting hole with a drill press.
- Option 2: Drill the pin-mounting hole with the T-nut clamped in place, using one of its alignment-pin clearance holes as a drill-bit guide.

Step 4: Remove the T-nut from the fixture component. Hold the alignment pin with needle-nose pliers, align it with the pin-mounting hole, and tap it into the hole with a small hammer. The tapping sound will change noticeably when the pin is fully seated.

Step 5: The alignment pin will typically have a tight friction fit in the wooden fixture. If it doesn't, remove it, add a drop of glue to the hole, and reinstall the pin.

Linear slides

Hornbeam T-nuts can also be used to attach sliding fixture components. To create a linear slide, place one or more Hornbeam T-slot washers between the T-nut and the fixture component. The washers fit within the slot opening, directly atop the T-nut, and are available in both 1/16" and 1/32" thicknesses. Make sure that the washer stack is thick enough that the fixture doesn't clamp down to the T-slot when the fastener is tightened.

To ensure that sliding T-nuts don't rotate and bind in the T-slot when the fastener is tightened, alignment pins should be installed for all linear-slide applications.



A linear slide assembly, using a T-slot washer only

Unless the sliding fixture component is made of a hard material, a larger washer should be installed atop the T-slot washers. This prevents them denting the sliding component, which would affect the sliding clearance. A 5/8" diameter general-purpose washer is suitable for this purpose, and will not interfere with the alignment pins. If desired, the 5/8" washer may be recessed flush with the bottom of the fixture component, to minimize the sliding clearance.



Slide assembly with general-purpose washer added

Hornbeam T-slots

Material selection

Most materials typically used for shop-made jigs and fixtures work well for Hornbeam T-slots. Almost any hardwood can be used at full rated T-nut load. High-quality hardwood plywood is another good material choice. In ultimate-strength testing, Baltic Birch plywood

performed almost as well as solid red oak. Even SPF softwood construction lumber performed adequately when tested with a 500 lb. load in a minimum-depth T-slot.

MDF, in contrast, is not suitable for certain Hornbeam T-slot applications. Pulling on MDF in a direction perpendicular to the sheet will separate the internal wood-fiber layers at relatively low forces. MDF T-slots are therefore unsuitable for anchoring pivot clamps and the like. However, MDF does have relatively good compression strength and shear strength. So Hornbeam T-slots in MDF are suitable for applications such as mounting stop blocks, where a flat-bottomed component is mounted directly against the T-slot, and the component does not pull outward on the T-slot.

CAUTION: Do not apply large upward-pulling loads to MDF T-slots.



A suitable clamping configuration for T-slots in MDF

For additional information on T-slot material selection, see Application Note AN-0130, *Hornbeam™ T-slot strength*.

T-slot depth

For adequate clearance between the top of a Hornbeam T-nut and a flat clamped object, the minimum T-slot depth is 7/16". This depth provides sufficient strength for slots milled in hardwoods, and is shallow enough to be milled in 3/4" thick material.

To increase the material-strength safety margin for softwoods, a T-slot depth of 5/8" is preferred. In tests using SPF construction lumber, the ultimate strength of a

5/8" deep T-slot was more than twice that of a 7/16" deep slot.

Distance from fixture edges

For adequate T-slot strength, sufficient material is required between the slot and the edge of the fixture component. Suggested minimum distances from the slot centerline to the edge of the fixture are as follows:

- Hardwood: 1"
- Softwood: 1-1/4"
- MDF: 1-1/2"

Milling Hornbeam T-slots

Hornbeam T-slots are milled to final shape with a Hornbeam router bit. For a Hornbeam Pro T-slot router bit, the router must have a 1/2" collet, and must be capable of routing at 18,000 RPM or less. For safety and accuracy, the router must be guided while milling the slot. When milling intersecting slots, best results are obtained by milling the cross-grain slots first.



A Hornbeam™ Pro T-slot router bit (RB0141)

Step 1: For ease of routing, first mill a rectangular starter groove centered on the desired T-slot location. The recommended groove width is 3/8" to 7/16". The recommended groove depth is 1/16" less than the desired T-slot depth. The chip-clearance

groove can be milled with a straight router bit, with a dado blade, or with multiple passes of an ordinary saw blade. Note that a starter groove is not strictly necessary if using a machine-mounted router with adequate power and rigidity.

Step 2: Set up a router guide. A router table with a fence is ideal for smaller workpieces. For large workpieces, a handheld router may be used in combination with either an edge guide or a clamped-on fence or guide rail.

Step 3: Install the Hornbeam T-slot bit in your router, and set the router speed to 18,000 RPM or less.

Step 4: Set the router depth of cut to the desired T-slot depth.

Step 5: Mill the Hornbeam T-slot to final dimensions in a single routing pass.

WARNING: Do not attempt to free-hand route a Hornbeam T-slot.

Recommended tools

A 5/32" T-handle hex wrench is ideal for tightening 1/4"-20 button-head clamp screws. If you keep a T-handle wrench handy, button-head clamp screws are almost as convenient as clamp knobs, and are much less expensive. High-quality T-handle hex wrenches are also inexpensive, so it may make sense to dedicate one to your Hornbeam jigs and fixtures.

A 7/16" combination wrench is the best tool for locking 1/4"-20 jam nuts on threaded posts. A "stubby" (short) wrench is ideal, as it fits into tight spaces and helps prevent over-torquing of the fasteners. This is also an inexpensive tool, so again you may wish to dedicate one to your Hornbeam fasteners.

An F size (0.257") drill bit is recommended for drilling clearance holes for 1/4"-20 fasteners. The extra 0.007" of diameter provides just enough clearance for your fasteners to slide freely in the hole.

Specifications

Patent www.toolquest.net/ip

Hornbeam T-nut

Body

- Length: 1-1/4" (32 mm)
- Width: 1-5/64" (27.4 mm)
- Height: 3/8" (9.5 mm)
- Material: glass-fiber-reinforced, engineering-grade thermoplastic
- Maximum working load: 500 lb.
- Ultimate strength: 2,000 lb.

Warning: Hornbeam T-nuts are not rated for lifting.

Caution: Using Hornbeam T-nuts above their rated working load may cause premature failure.

Threaded insert

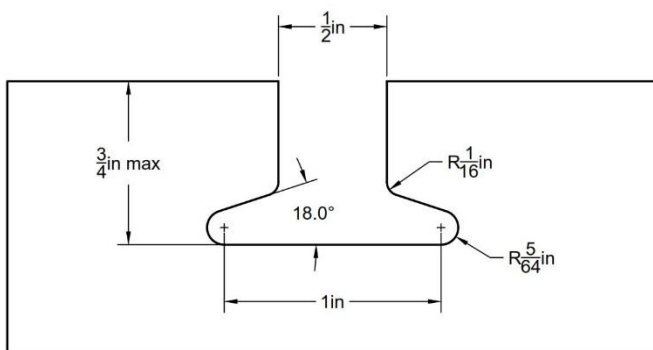
- Thread size: 1/4"-20 or M6-1
- Material: brass

Alignment pin holes

- For pin diameter: 3/32" (2.4 mm)
- Center distance from mounting screw: 25/64" (10 mm)

Hornbeam T-slot

- Dimensions: see profile drawing
- Minimum depth: 7/16" (11 mm)



Hornbeam™ T-slot profile

Hornbeam Pro T-slot router bit (RB0141)

- Shank size: 1/2" (12.7 mm)
- Maximum speed: 18,000 RPM
- Maximum depth of cut: 3/4" (19 mm)