WHITE PAPER:

WHEN TO USE SCREWS OR PEM® TACK SOLUTIONS

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OVERVIEW

There are many cases where two or more items need to be held together, and many product designers have historically defaulted to using a screw; however, a screw is frequently not the optimal solution. This paper explores and contrasts two joining techniques: screws (defined as a machine thread with a head and driver that is mated to a nut or threaded hole) and PEM® Tack solutions (TackPin® or TackSert® fasteners). Many factors should be considered when choosing a fastener to hold two or more items together, including:

- Mechanical performance characteristics
  - Clamp requirements
  - Joint strength and failure modes
- Manufacturing and assembly
  - Required preparation
  - Assembly requirements
  - Assembly failures
  - Rework after failure
- Use features
  - Need for removability / reuse
  - Aesthetics and form factor

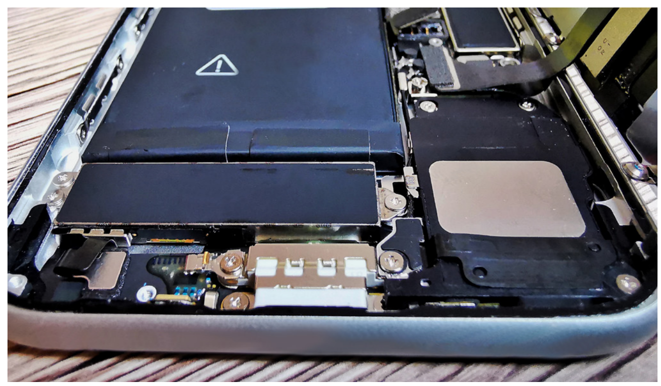
In some cases, screws are the right solution. In fact, they may be the only solution. But in many cases, bypassing the screw in favor of a Tack solution from PennEngineering® can deliver dramatic improvements.

MECHANICAL PERFORMANCE CHARACTERISTICS

The performance of a joint can be measured in several ways. This paper will consider the joint as a construct intended to hold two or more components and will examine the fastening elements themselves.

Clamp Load

A threaded joint will typically provide clamp load: A lasting force joining the mated components and resisting working loads and vibrations. This is accomplished by engaging a screw into a nut or threaded hole and applying torque to stretch the screw and compress the joined members. The materials are deformed to a point below the yield strength within the elastic zone of the materials, which causes the clamp force. This is called generating a preload. Clamp load is typically only required if the joint is expected to see cyclical loading or loads that will attempt to separate the components in a case where any separation could result in failure. In most light-duty applications, clamp is not necessary.



However, to generate clamp, there must be enough length between the head of the screw and the start of the mating threads. Without enough length, the stretched and compressed elements are unlikely to develop a clamp, and if they do develop a clamp it is unlikely that it can be maintained. The required length is largely a factor of the material properties of the screw and the clamped elements. Very stiff elements with a high elastic limit will work particularly well, but softer elements or materials that will take a set with time, (permanently deform under pressure over time), such as plastics, do not perform as well in this scenario, and therefore will not provide a reliable clamp load.

Next, the thread must be engaged enough to hold the clamp load generated. Enough threads of the screw must be engaged with the threaded hole to resist the axial load. For very short, or shallow, tapped holes, this can be challenging. Typically, a blind tapped hole will require:

- A countersink to allow easier thread engagement.
- One to three dead-threads on the tap to allow for cutting.
- A dead-space at the bottom of the hole to allow the tap point and provide space for tolerance accommodation for the machining operations.
- A drill point angle on the hole itself.

All of these reduce the actual engaged threads that can resist the axial load generated by clamp. With too few engaged threads, the thread will fail prior to clamp being generated.

For these reasons, especially in short joints holding a thin element or engaged into a shallow, blind hole, the joint will not generate the expected clamp load but will simply snugly hold the components together in the best-case scenario, or the joint will fail. This failure may be immediate during the tightening process, or later under load or under vibratory conditions in service.

In comparison, a Tack product will not deliver a clamp load because no elements are being stretched in the joint. A good installation will snugly nest the components together but will not provide clamp; however, the installation process cannot fail the joint in the same way that a thread can.

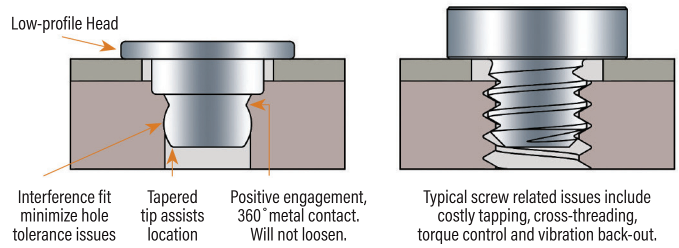
In summary, a Tack product will not deliver clamp load, but a screw may deliver clamp load under the right conditions. The joint designer should consider if a clamp is necessary or if a snug fit is sufficient. If clamp is truly required, the joint designer should ensure the design allows for the generation of clamp and resistance of the forces generated.

Fastening Elements

It is also important to consider several other factors of the joint which are interconnected to the above points. Head strength is important primarily in the case where strong clamp is needed and significant forces are working and/or cycling against the joint. In these cases, it is important to have a head strong enough to withstand the clamp and load conditions, and large enough not to yield the clamped materials.

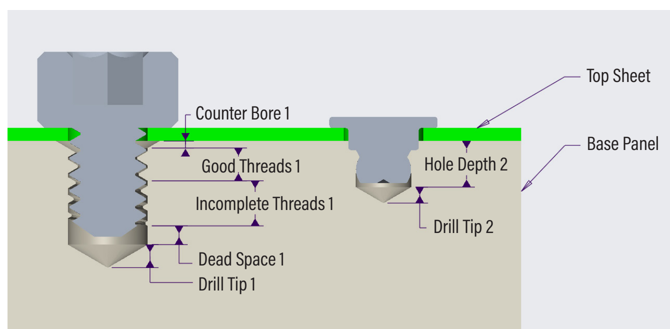
In most light-duty cases, however, the loads are very low, so the fastener head can be much thinner. This can be very advantageous in applications where space (z-height) is constrained.

Screws generally must have a thicker head both for loading constraints and to allow the screw to be driven. Internal drives (typically Phillips, slots, hex and lobes, to name a few) require a thicker head. But even external drives (typically hex or square) need sufficient height so a wrench can drive the screw with the necessary torque without damaging the head itself.



Tack fasteners, on the other hand, need only as much head height as the forces working against the joint require. There are no internal or external drivers. This enables PEM® Tack products to have very thin heads, making them particularly well suited for space-constrained applications.

Another important consideration is the strength of the screw to the threaded hole or nut. A screw should turn past a nut by at least the major diameter of the thread to achieve a good joint to account for incomplete threads on the end of the screw and both ends of the nut. A blind threaded joint should have at least 1.5 times the diameter of the screw of engagement for the same reasons. Many applications, however, don't achieve sufficient engagement, resulting in only a few fully developed threads in contact. This leads to weak thread strength and stripping failures (typically failing the nut).



In comparison, Tack fasteners have no threads. They can go into a blind hole without threads and are pushed to install. The lack of threads allows them to remain in position during use without loosening over time. This significantly simplifies the design constraints and eliminates difficult to discover field failures.

MANUFACTURING AND ASSEMBLY

Hole Preparation

When using a screw, a nut or a threaded hole is required. Threaded holes must be properly prepared. Drilling and countersinking a hole in the chassis typically requires two turning operations unless the chassis is a casting or mold with the proper orientation. Afterwards, another operation taps the hole, putting in the threads. When a blind tapped hole is used, the amount of threads that can be placed is significantly limited (as noted above), so only a few usable threads are available. Tool wear and breakage (drills, countersinks and taps) can lead to high tool costs and process variation. In some materials, the generation of chips or swarf can also be problematic. Going beyond a cleanliness perspective, chips or swarf from some alloys, i.e., magnesium, could present a flammability danger. For some plastics and metal alloys, the generated chips may be carcinogenic or otherwise harmful to the people working around them.

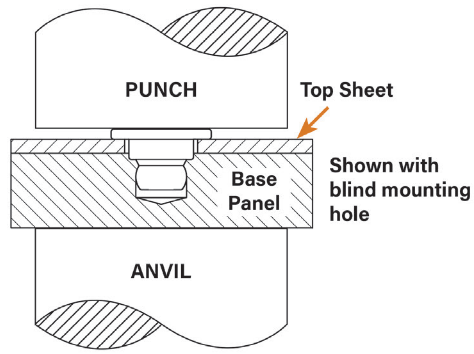
A Tack fastener requires neither a tapping of the hole, so no chips or swarf are generated, nor a countersink feature. This eliminates two of the three operations required for machined chassis. In the case of castings, and molds with proper orientation, it eliminates all secondary operations to prepare the hole for the fastener. Eliminating these steps removes the costs associated with processing, tooling and any potential rework or quality issues. The Tack fastener also reduces variation due to fewer operations and touchpoints required.

Engagement

When a screw engages a nut, both items are free to turn; therefore, one must be constrained from motion while the other is driven. Typically, a wrench or a cavity in a casting/mold prevents the nut from rotating and the screw is driven directly. This approach adds design constraints and complexity to the installation.

The thread strength issue described above is compounded by the need to tighten the screw. Relatively high torques are needed to clamp down the joint, but if there are only minimal engaged threads, the torques can strip the threads prior to proper seating. In these cases, the screws may spin in the holes and seem to be installed, but are actually loose. These uninstalled screws can fall out later during shock-and-vibe testing or real-world conditions, causing shorts and other issues inside the chassis. Thread-locking patches on the screws worsen this condition because they increase the tightening torque required and can further mask a failure.

A Tack fastener, in comparison, does not rely on turned threads or any applied torque. As such, there are no threads to fail and there is no way to over-tighten and destroy the fastener. Because they are installed with an axial force with a high tolerance allowance, it is easy to ensure they are properly installed. This eliminates concerns over failed joints.



Use Features

There are two main use features that a designer should also consider: removability and cosmetics.

Removability is clear on one side: the PEM® Tack fasteners do not remove. They are intended to install easily and not be removed. This makes them optimal for non-serviceable items and areas that are not intended to be tampered with.

With screws, removability is less clear. A properly designed screw can typically be removed. Removability and clamp requirement are the two primary reasons to use a screw over a Tack fastener. However, often the screw has too short engagement, uses locking patches and has a weak, shallow driver. All these variables can lead to cases where the screw cannot be removed, and in fact is locked into place. It is also noteworthy to point out that many applications where screws are used are not intended to be serviced or accessed, or are assembled and not intended to be removed. In these cases, using a screw instead of a Tack fastener typically is unnecessarily expensive and subjects the product to potential failure down the line.

In the field of cosmetics, everyone is their own judge of beauty. Screws can provide a mechanical look and add charm and distinction. Typically, the heads sit noticeably on the surface and the driver is displayed prominently. But, they are often very visible and distinct and can disrupt aesthetic lines.

Tack fasteners have round heads. Lower to the surface and uninterrupted by a driver, they are typically less visible and noticeable on an application. They can also be used to facilitate thinner, sleeker designs to optimize space.

Conclusions

While screws and PEM® Tack fasteners both serve the general purpose of holding multiple components together, they do so in significantly different manners. Screws are the more expensive solution when the entire cost to install is considered, but can, when designed properly, provide both clamp and reusability.

PEM® Tack fasteners are less expensive to install, fit within a smaller envelope, provide better process control, and reduce opportunities for field failures. Their head styles are more conducive to cosmetic applications and their design allows for thinner applications. Unless clamp load or removal is required and can be adequately designed for, PEM® Tack fasteners deliver many advantages, including a much lower total installed cost and enabling a sleeker cosmetic profile.