A Spectrum of Fasteners

by Peter Standring

In considering a 'spectrum' of fasteners, it might be reasonable to place 'permanent' fasteners at one end and 'non permanent' at the other. A definition of 'permanent' could mean a rivet on a ship's hull or fastener for a luggage case handle. 'Non permanent' fasteners could be a vehicle seat belt fixing or a simple spring clip. The middle ground of the spectrum would include the range of 'flexible' fasteners as described in a previous Fastener World article.

Of course, the term 'permanent' fasteners would include all the growing range of 'security' fixings which are specially defined to be 'tamper-proof.' These would be graded into the types of fasteners which were impossible to remove without being destroyed and those which could be removed if the correct tooling were available. Interestingly, whilst the connotation of 'security' fasteners conjures the desire for 'anti-vandal' protection, it is probable that far more security fasteners are designed to prevent unauthorised access to the inner workings of items such as: smart phones, white goods and machine control systems.

Moving further along the spectrum, the term 'semi permanent' fasteners are used to describe the vast multitude of screws, nuts and bolts which once employed would never be expected to be removed but if necessary could be.

These include fasteners used in steel work construction, anchors in concrete, long and short wood screws along with nails and fitments for any and every situation.

Next would be the 'flexible' fasteners described previously. In many cases, these would be 'permanent' in the sense that they would remain embedded in the role for the life of the requirement but could also translate and/or rotate within the six degrees of freedom along or around the three cartesian axes. A good example would be the rubber mounted suspension/steering joints found on most passenger vehicles.

At the extreme end of the fastener spectrum would lie the 'non permanent' fixtures. Simple consideration of every day life indicates how numerous and varied these are. For example, fridge magnets, symbolic wall mounted magnetic year planners, double sided tape, adhesive non setting tack etc., etc., etc.. Any serious attempt to 'classify' this end of the spectrum would require many sub–sub sections.

To simplify matters, in this article, 'non permanent' fasteners will be confined to metal based products in which their functional requirements have a 'safety' element.

Figure One provides an illustration of the fastener 'spectrum.' The scale of the 'spectrum' is not in anyway indicative of the size or relative importance of one section to another. It simply serves to represent the types and variety of the family of fasteners in the context of their use. It is the two ends of the fastener spectrum which will be discussed here.

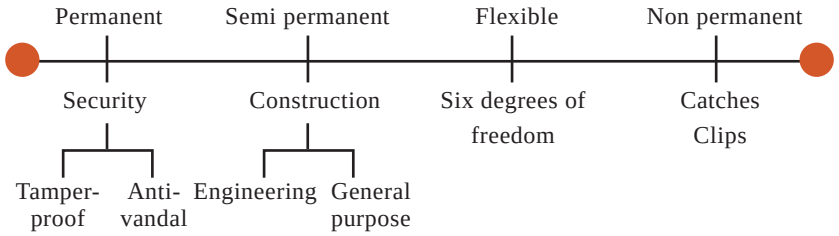

Figure 1 A proposed 'spectrum' of fasteners

Security Fasteners

It is a simple matter to design a threaded fastener (nut or screw) where the torque it is tightened to is the same as the shear–yield stress of the material the part is made from. Without any evidence to support the claim, this practical knowledge must have been obtained long before people were able to calculate and predict the loadings at which this occurred! Moreover, as most folks will have discovered, when a tap or a screw shears, the repair job will take significantly longer and more effort to remove it than the initial task. There are many examples throughout history when one or a number of quick thinking individuals recognised that a failure could be turned into an asset. As mentioned previously in an article discussing the Archimedean Screw ("Following the Thread", Fastener World Issue 168, Jan/Feb 2018, pp 326 - 330) someone watching a fruit or a shoe being translated in the water column could have realised that if the screw rotated in a threaded body (a nut) then one of the elements would translate relative to the other.

The design of anti-vandal fastening devices is primarily based on the design of the driver used to apply the action. The fastener is often a threaded screw although it could be a spring clip. Figure Two shows how the torque required to tighten a thread is unidirectional meaning that using these head designs, it would be impossible to generate any force when trying to remove it.

Figure 2
Right hand (clockwise) head design

Companies working in the field have developed designs where using special purpose tooling this type of fastener can be removed. For the casual vandal, such fastening devices are a hundred percent successful in deterring damage. However, for the independent repairer of electrical or electronic devices often costing many hundreds of US dollars, the failure to obtain the correct tools to remove a cover means zero opportunity for business. Of course in such situations if the customer requiring a repair must use an OEM authorised outlet, then the price will be commensurate with the service – generally very expensive.

A common way to describe security fasteners of the threaded type is to call them, One Way (fixed) as in Figure Two, or Two Way (removeable). On the One Way type, in Figure Two or when the driving element (normally the head) shears off at the desired clamping load, a successful application will have been achieved. Of course exactly the same principle when applied to a 'shear pin' coupling two axial driving shafts together would indicate complete failure.

Without any supporting evidence it is highly likely that One Way fasteners resulted from the product of failure to unscrew early type fastener heads. 'Caming out' or shearing the back edge of a simple slotted head screw (when trying to remove it along with shearing of the head) must have been the pain of most users – as indeed they still are today. Again, some resourceful souls, probably those having a philosophy of a glass being half full rather than half empty, will have recognised how this type of failure could be turned into a commercial success by simply manufacturing them.

Unlike the fastener designs shown in Figure Two, most vandal proof security fasteners utilise common head drive design like Phillips, Torx, Hex, Square etc. but with a small pin upstanding in the centre. Shown in Figure Three, this simple device makes it impossible to use a standard tool to influence the fastener but using a modified tool, it can be removed hence the Two Way security fastener. So common is this method, some fastener manufacturers will provide their customers with a guaranteed, completely unique driver/tool design, for the right price of course. Such specialist items are now quite commonplace and can be found on most 'branded' golf equipment like the threaded fasteners on drivers and woods. These require special torque wrenches to achieve change or adjustment. The use of two pin wrenches are also used to fasten cleats to spiked golf shoes.

Figure 3 Upstanding pin makes the use of standard tools impossible.

The use of pins, nails, staples etc., are probably the most common types of non-threaded 'permanent' fasteners. In our eco-conscious world this now includes wooden nails, power tool driven into laminated wooden buildings, as replacements for standard metal based fasteners. Perhaps the joint designs of medieval wooden constructions will remerge as a centrepiece of future sustainable living?

The use of split pins to lock nuts and keys to prevent shaft/item rotation, along with circlips (constraints rings) to ensure no translation takes place, are all types of semi permanent non threaded fasteners.

Non Permanent Fasteners

All restrain harnesses from baby buggies to parachutes use non permanent fasteners. Naturally their role is to secure people and things, most often during transit and then to effect a release when needed to do so. Such release mechanisms are normally termed 'quick' although the speed of action is generally commensurate with the urgency behind it. Unhooking a child from a car seat in a parking lot may be awkward for the parent but it wouldn't be considered as being too urgent – depending of course on the circumstances! On the other hand the activation of an ejector seat in a jet airplane must be rapid enough to the fire the unfortunate aircrew well clear within perhaps fractions of a second.

Quick release mechanisms are also found on all manually operated (non CNC) machines where a nut translated by a leadscrew must drop out precisely when required to do so. The same is true for mechanical, pneumatic/hydraulic workholding devices and for latches, locks and all devices which secure gates, doors and entrance/exits.

Clearly, in many situations such non permanent fixing devices would/could be considered as 'flexible' fasteners since to operate, they need to move as in the case of a simple bolt. However, a subtle distinction may be made between say a rifle bolt which would require first a rotation followed by a translation to achieve its function. Once a round had been fired the cycle would be repeated. The comparison with a similar bolt which secured the door of a premises would not be considered as being 'flexible', since when locked, the bolt could reasonably be expected to remain in that condition for some time but not permanently.

Conclusions

A 'permanent' fastener must be one in which the design function required is never changed. Drilling out a rivet will naturally remove the fastening element and therefore destroy the function. Similarly a One Way threaded fastener could be removed if it had a centre hole drilled through it without damaging the thread. Then an opposite handed tapered threaded tool could be used to extract the headless element thus rendering it non-permanent but of course that would mean it would be inappropriate for further use.

In all other cases considered in the fastener spectrum, it is the timeline which determines the fastener function. The various methods and systems employed in the fastening process by dint of there only being six degrees of freedom must therefore be the same. For that reason, it is the balance between speed of operation, environment of use and specific design function which determines where a fastener will be placed on the spectrum.

An excellent example is that shown in Figure Four. As can be seen, both parts are quite old spring loaded carabiner used with ropes for climbing and securing loads. On the left is a simple clip on device which is quick acting. The one on the right is fundamentally the same except this also includes a knurled threaded cap nut which can be screwed across the moveable element

to secure it 'permanently'. In use, the right hand carabiner is employed by the climber to secure the body harness which remains fixed during the climb whilst the quick attachment and release type on the left, forms a collection of jangling devices clipped to the harness and used as climbing aids during the activity.

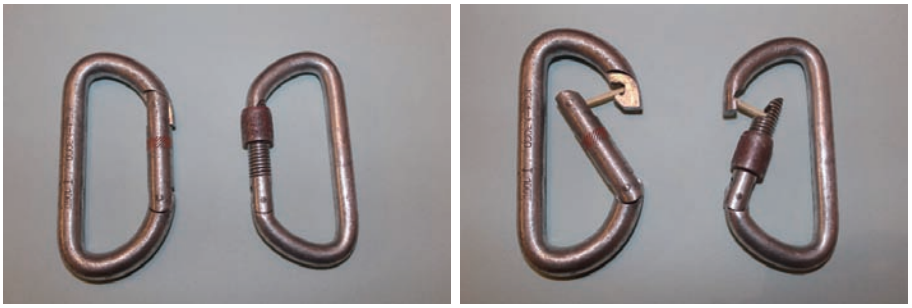

Figure 4 Spring loaded carabiner (left), nut secured (right) (courtesy KMS)

It is interesting to note that whilst scientific discovery is at the forefront of creating the world in which we live – just note the many spin-offs which have resulted from the exploration of Space – on a practical level, 'Necessity' is still the Mother of many inventions. At one level are disenfranchised people who require the basics of water, food and medicine to survive. Often it falls to students working with Non Government Organisations (NGO's) who try to provide low cost solutions to these problems and in doing so come up with interesting ideas for fasteners.

Poles apart are those who often dwell on the fringes of rich societies and who dedicate their lives (quite literally) to advancing the obsession they have to 'extreme sports' e.g. base jumping etc.. Working with often very limited resources and where legal issues are involved, sometimes in secrecy, these people who act as their own life/death test houses, make remarkable contributions in pushing the boundaries of possibility way beyond any which the vast majority of people would ever dream of.

Titanium ice screws, microlight aircraft, hang gliding and the so many more recent developments of seemingly crazy sports which have now become, or are in the process of becoming mainstream, enter the mind. This must be fertile ground for those seeking to commercially develop what tomorrows fasteners may look like and be required to provide?