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Grupo CELO

Technical handbook-Screws for metals

CELO
Screws Technology

Technical handbook - Screws for metals

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When one thinks about screws for metals, the first image that probably springs to our mind is a metric threaded screw with a nut or perhaps a self-tapping screw ...Why to write a booklet about these parts? It seems that little else new can be said about them.

In fact, there are endless international norms and studies about their geometries, dimensions, tolerances, steel qualities, coatings, etc....

Our day to day experience with different sectors of the industry shows us that our customers' engineering and production departments have no "theoretical" problems regarding thread design, dimensions or the steel quality to use but on a daily basis.

However, they come across much more practical problems that are often very difficult to solve as there are no standard solutions nor international guidelines to be followed. For example:

- How can I eliminate drilling, tapping and threading operations from the manufacturing process and reduce assembly costs?
- How can I avoid vibrational loosening?
- How can I avoid thread stripping in thin metal sheet?
- How can I improve pull out resistance for an aluminium assembly
- How can I hold a circuit board in place on an aluminium base without damaging the circuits?

These questions and many others are asked day by day to our Technical Sales department. It is useless to say that we don't have "miracle solutions", but our many years of experience and our wide range of screws for assemblies on metal allows us to find some good answers for our customers.

Moreover, CELO puts its testing laboratory at your disposition to carry out the necessary tests for "YOUR specific requirements" to determine "YOUR best solution", not only regarding fixing safety but also on how to reduce assembly costs, how to automate production lines, how to ensure ergonomic assemblies, how to improved the aesthetics of the finished product, etc.

This 'Screws for Metals Handbook' gives some basic criteria to take into account when designing a metal or alloy assembly. We hope that you find it useful and do not hesitate in contacting us if you have any doubts: we are at your service.

Before ending this brief introduction, I would sincerely like to thank all those that have made positive comments regarding our first Screws for Plastics manual. Clearly, those favourable comments have motivated us to produce this second handbook, which we also hope you find interesting.

Ramón Ceravalls,
Managing Director.

1 METAL TYPES

Science and Engineering breakthroughs in materials have solved a large variety of problems (mechanical, electronic, rusting, aesthetical, weight etc...), that until now were impossible to tackle with existing materials.

In the case of metals, alloy design possibilities are nearly infinite and have had a decisive influence in industrial scientific and economic development. Below is a brief overview of the most used metals and alloys for industry.

Metals can be divided into two groups: ferrous and nonferrous.

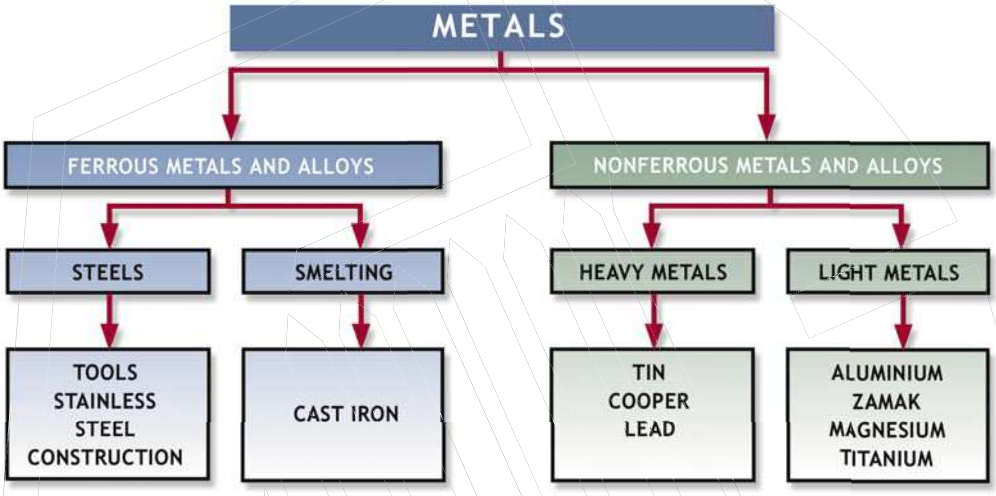


Figure 1

1.1 Ferrous Metals and Alloys

This large group of metals contains iron as their base, with iron itself and steels (steel – carbon alloys).

Although in the last 30 years there have been great steps forward in the use of other metallic materials, iron and its steel alloys are still the most produced and used metals; 20 times more is produced than any other metal. The main reasons are:

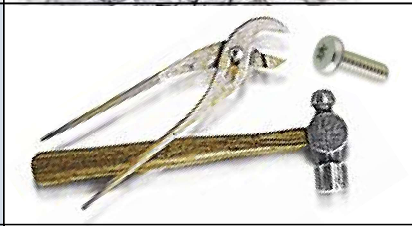
- Abundant in nature in a highly pure state (high-quality one).
- Cheaper to obtain compared to other metals (easier to smelt).
- A large variety of alloys derived from combining with carbon.

The main iron and steel industry product is carbon steel, of which approximately 10% can be other additional elements that modify its mechanical or tempered properties. This last group is referred to as steel alloys.

Carbon steel has a complicated chemical composition. Iron content oscillates between 97% and 99.5% and carbon does not normally exceed 1.76%. Generally, an increase in carbon content in steel increases its pull out resistance, while in the other hand increases its brittleness and reduces toughness and ductility.

We can add other alloy elements such as nickel, magnesium, chrome, vanadium, wolfram, molybdenum, etc... to make steel alloys. The influence they have is varied, and used in convenient quantities we can obtain steels with different mechanical, electrical or anticorrosion properties that cannot be obtained using ordinary carbon steels.

Steels can be classified in different ways but regarding their properties and use, they can be divided into three groups.

Steel type	Properties	Use	
Steel for construction	High mechanical resistance	Machine parts or elements, engines, building, rails, vehicles	
Steel for tooling	Steels used to modify shape, size and dimensions, cutting, pressure or drilling	Tool manufacturing	
Stainless steels	The main feature of these steels is their high resistance to rusting: the passive film formed by chrome (minimum 12% content) leaves the steel surface inert to rusting reactions.	***Martensites:*** Knifing, axles, bearings and surgical instruments. ***Iron based:*** Domestic utensils and decoration. ***Austenitic:*** Machines and tools for the food and pharmaceutical industries.	

STEEL MANUFACTURING TABLE

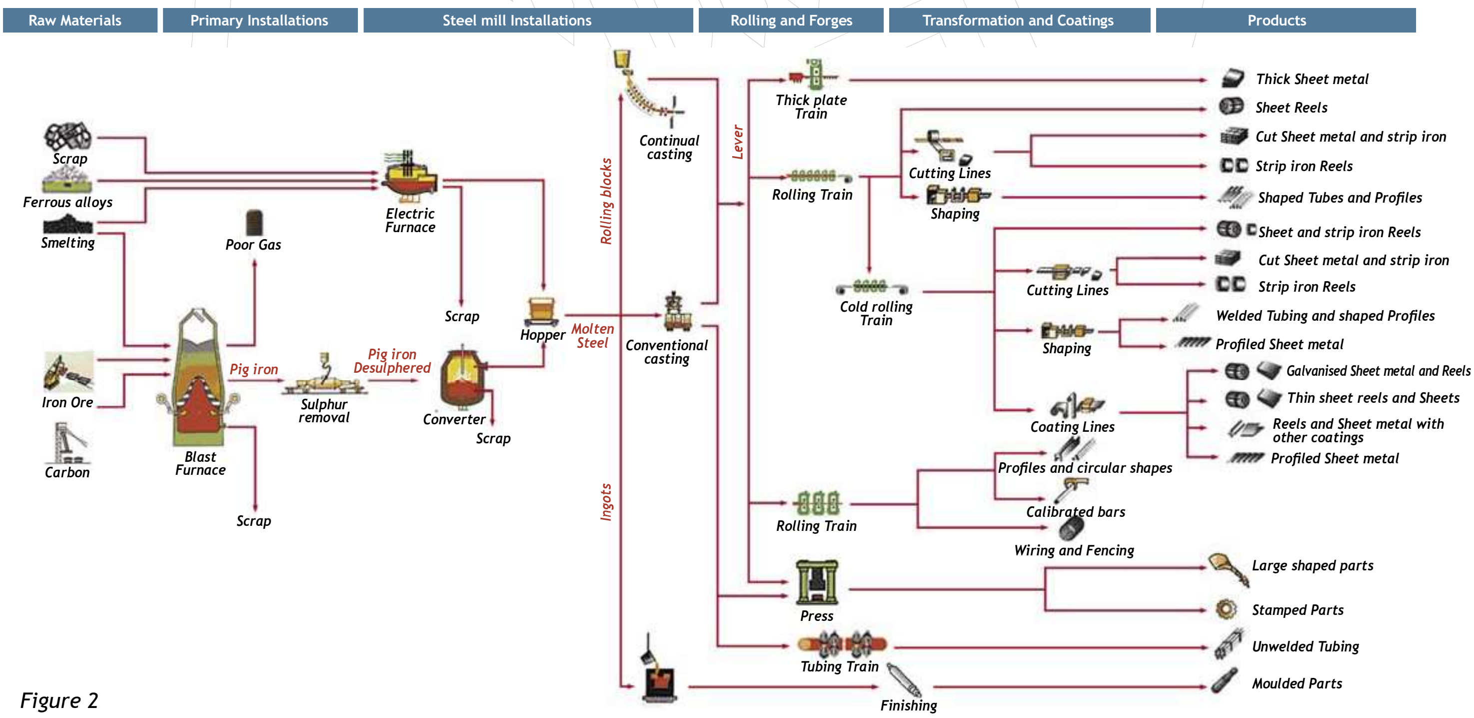


Figure 2

To manufacture steel we can start from:

Iron ore that is heated in a blast furnace along with coke (carbon), Oxygen and limestone.

Scrap, which is placed in an electric arc furnace to melt the scrap.

Although the steel quality is much better in the first process, nowadays, refining techniques achieve quality steel products from scrap.

1.2 Nonferrous Metals and Alloys

Traditionally used nonferrous metals have been copper, lead, tin, zinc, as they were easily obtained through mineral fusion. Others such as aluminium and magnesium have required higher technology to produce them and despite being abundant in nature, they have only been available to man for the last 100 years.

The most difficult to obtain by smelting have been titanium and magnesium. Initially used for aerospace industry, their production cost has been greatly reduced in the last few decades. Currently, they are starting to be used in different industrial sectors for their lightness and mechanical resistance.

Metal	Density (g/cm^3)	Relative Cost	Pressure Resistance (PSI)	Pressure Resistance (Kg/cm^2)
Magnesium	1,74	15	55.000	3.867
Aluminium	2,70	6	83.000	5.835
Titanium	4,51	50	160.000	11.248
Zinc	7,13	5	75.000	5.273
Iron	7,87	1	200.000	14.060
Nickel	8,90	40	180.000	12.654
Copper	8,93	10	150.000	10.545
Lead	11,36	3	10.000	703

Figure 3
Comparative resistance and cost table of different metal elements.
1 PSI = 0,07 kg/cm^2

1.2.1 - Aluminium

Aluminium is the second most abundant metal on earth (7.5% of the Earth's mass) but due to the large amount of energy needed to produce it, a regular supply has only been achieved in quantity and quality since the last third of the 20th century.

Aluminium alloys are the most important nonferrous alloys for their lightness, formability, being non-corrosive and their interesting mechanical properties. Their uses in the automotive sector have decisively contributed to a weight reduction in vehicles and consequently fuel saving and CO_2 emissions reduction.

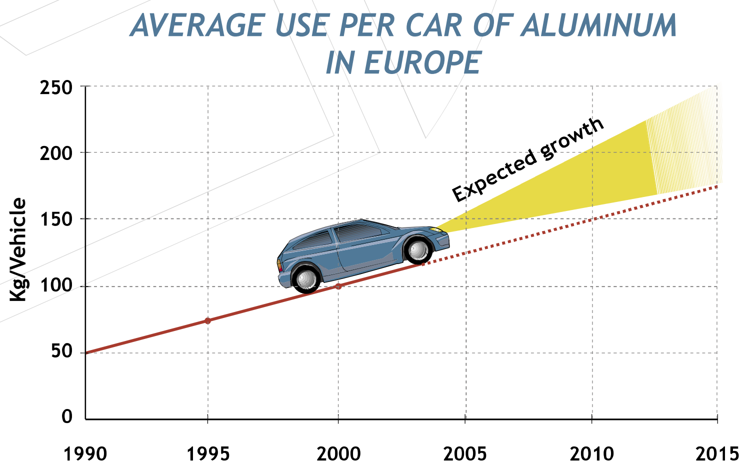


Figure 4
The average weight of aluminium used in the automotive sector has doubled in the last 10 years and a greater growth is forecast for the next 15 years.

Advantages using aluminium are:

- ***Low density,*** three times lower than steel. Only lithium, beryllium and magnesium are lighter than aluminium.
- ***Fairly good mechanical properties,*** which can be improved by using alloy elements and special heat treatment.
- ***Non-corrosive:*** the oxide film formed in contact with air permanently protects it from corrosion.
- ***Easy to recycle:*** recycled metal only requires 5% of the energy needed to produce the same quantity of aluminium ore (from alumina).
- ***High thermal and electrical conductivity.*** Its conductivity is 1.8 times greater than copper and 3 times greater than steel.
- ***Relatively low cost*** compared to other light alloys such as magnesium.
- ***Easy to machine,*** it can be lathed at higher speeds, which contributes to cost reduction.
- ***Many ways to be shaped:*** stamping, extrusion, die casting, forging, folding, cutting, drilling, machining...
- ***High kinetic energy and vibrational absorption:*** Aluminium can absorb at least twice the energy form impact compared to steel.

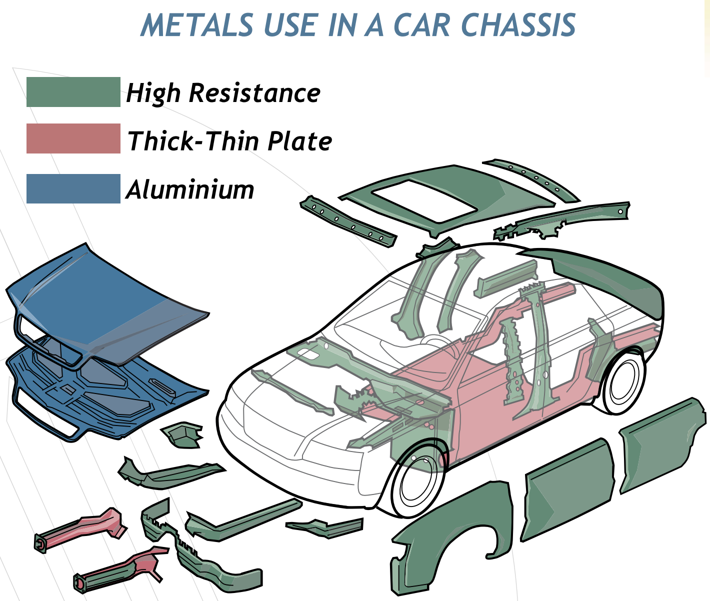


Figure 5
The use of aluminium for vehicle front parts allows absorbing twice the kinetic energy from head-on collisions.

1.2.2 - Zinc - Zamak Alloys

Originally developed in 1931, Zamak is the commercial name given to alloys made from zinc combined with small quantities of aluminium (3.9% – 4.3%), magnesium (0.03% - 0.06%) and eventually copper (1% - 3%). These elements allow changing the brittleness of pure zinc to a metal alloy with greater hardness, improved mechanical resistance and good ductility.

It was initially used for decorative parts but began to be used in engineered parts because of its low production costs, faster die casting and the possibilities to achieve accuracy for details and tight tolerances.

Zinc alloys and their features:

- ***Mechanical resistance comparable to aluminium.***
- ***High thermal and electrical conductivity.***
- ***High dimensional precision*** and die casting stability.
- ***Highly resistant to corrosion.***
- ***Recyclable.***
- ***Fast die-casting,*** due to its low melting temperature (379° - 390ºC). Highly complicated parts can be obtained faster through die-casting.

VERY IMPORTANT: ZAMAK MUST NOT be used in applications exposed to high temperature and fatigue cycles.

There are six different types of zinc alloys that differ by some of their components such as copper and magnesium. Choosing one or the other is linked in part to the geometry of the finished part and its end use.

Zamac Type	Properties and Use
Zinc 2 alloys	Used for moulds manufacturing
Zinc 3 alloys	Highly complicated geometrical parts and sharp contours
Zinc 5 alloys	High dimensional stability and easy to die cast, applied in carburettors, water and petrol pumps.
Zinc 7 alloys	It improves when molten. Used in household appliances such as extractors, fruit juice squeezers and other hard parts.
Zinc 10 alloys	The most economical, used for trophies and all parts that do not require good finishing.
Zinc AZC alloys	Finishings for handbags, shoes, rucksacks, key rings, etc.

Figure 6
Complicated geometrical parts with fast die casting speeds can be made with zamac.

1.2.3 - Magnesium

Magnesium is the lightest structural metal with a density of 1.74 g/cm3, compared to 2.7 g/cm3 of aluminium and 26 % less energy requirements for its manipulation.

Regarding its **mechanical properties, magnesium alloys are not as resistant as aluminium alloys** but their specific resistances (resistance/weight) are comparable.

Magnesium alloys and their features:

- ***Lightness:*** it is ***the lightest*** of all the structural metals, 33% less than aluminium and 77% less than steel.
- ***Hardness:*** Good hardness and ***excellent resistance / weight ratio.***
- ***High conductivity:*** electrical as well thermal.
- ***Resistance to high working temperatures.***
- ***High dimensional accuracy and stability*** when die-casting.
- ***Highly fluid:*** which allows achieving thin wall thicknesses and contributes to cost saving.
- ***Good finishing features.***
- ***Recyclable***
- Economical advantages compared to plastics and even aluminium [1].

Figure 7
Automotive alloy wheel trims are traditionally made from aluminium for its lightness. A few years ago, the industry started to use magnesium for the weight saving involved in the racing world. Nowadays, the more luxurious vehicles have magnesium trims as an option for more enthusiastic clients.

The main technical reason why magnesium is less used than aluminium is its bad corrosion behaviour in aggressive environments: it is not suitable for marine environments and produces galvanic corrosion in contact with other metals (magnesium has low electronegativity value). That is why its main industrial uses are for internal parts although recent innovations in anticorrosive coatings shed some light on external uses.

Magnesium decisively contributes to weight saving needs in parts in different industrial sectors. Its use in the automotive and electronic sectors has increased 350% in the last 10 years and a 25% annual growth rate is forecast until 2008.

(1) *Until a few years ago, magnesium was much more expensive than aluminium but its price has reduced considerably.*

1.2.4 - Copper alloys

Copper is one of the most widely used metals since prehistoric times. Due to its extraordinary conductivity, its main use is in the electrical industry.

Copper-based alloys are heavier than iron alloys but have widely been used for their excellent ductility, being easy to weld, being anticorrosive and having very good thermal and electrical conductivity. From the varied alloys, we will focus on the most common ones: brass and bronze

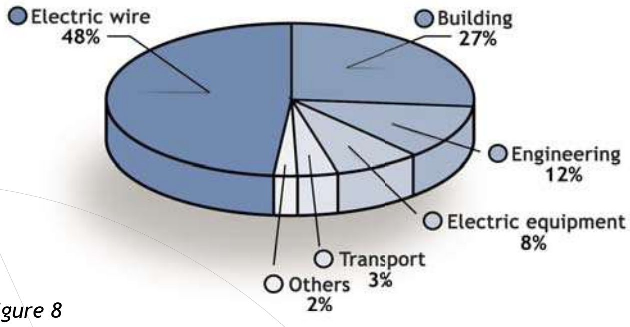


Figure 8
Copper is mainly used in the electrical sector and construction for its high conductivity.

Brass

Brass (also called yellow copper) is an alloy of copper and zinc, in which zinc is added to improve its mechanical properties. The most common brass alloy contains from 30 to 35% of zinc in order to reduce the cost, increase ductility and formability. By reducing its zinc content, the brass alloy becomes closer to copper and its properties, improving its corrosion resistance.

Brass can be forged, hot or cold laminated and extruded from which we can obtain bars, sheet metal, wires, profiles, tubing, etc...

Although it is a heavy alloy, it is greatly used in industry to make electrical accessories, instruments and parts in general that need to work in humid environments and have good thermal and electrical conductivity and in varied environments such as naval construction or plumbing.

Bronze

Bronze is any copper alloy, usually with different proportions of tin[2], which can contain other elements such as zinc, lead, etc. Bronzes can be easily moulded or machined.

They are widely used in manufacturing parts exposed to high friction, such as bearings, valve and tap parts, pump wheels, gearing, etc.

1.2.5 - Nickel - Monel Alloys

Monel is the commercial name for nickel (67% to 70%) and copper alloys.

The mechanical resistance of the alloy is somewhat greater than nickel alone without sacrificing ductility and has a specific weight of 8.8 g/cm^3. Nickel – copper alloys basically keep the excellent malleability and welding capabilities of nickel; they can be forged, laminated and extruded, from which we can obtain bars, sheet metal, tubing, wires, etc...that can be machined or welded.

Owing to their good thermal conductivity and anticorrosion qualities, Monel is frequently used in heat exchangers, condensers, pumps, valves.

(2) *Bronze is a copper-tin alloy, however, in fact bronze alloys may not necessarily contain tin and other elements such as zinc, aluminium, beryllium, phosphor, silicon and lead can be added, which improve its mechanical qualities with or without thermal treatment.*

2 METAL JOINT TYPES USING THREADS

Once we have reviewed the most commonly used metals in industry, we will analyse the existing alternatives for joining metal parts. We can basically divide metal joint types into four large groups.

- By welding.
- By riveting parts or by using a pin.
- By chemical adhesive.
- By using male and female thread.

Each of these four systems has its advantages and disadvantages that must be considered when designing the assembly of metal parts. There is abundant theoretical and practical bibliography available for each of these methods, which we have no intention of substituting. CELO's objective when editing this manual has only been to summarise our practical knowledge and experience for solving problems, as well as to provide solutions for threaded joints.

2.1 Advantages of Threaded joints compared to other systems

- Enables joining ***different materials with different shapes***.
- The possibility to ***choose different thread types*** according to assembly needs: mechanical resistance, anticorrosion, electrical conductivity, etc...
- ***Easy to insert and automate***, as in industrial serial mounting or in construction.
- ***Reusable:*** enables manipulation and removal once inserted (especially important for parts that need maintenance or including the sometimes unavoidable assembly line reprocessing).
- ***Easily recycled:*** Assembled parts can be separated quickly.

Figure 9
The assembly speed and reusability for threaded joints is difficult for other assembly techniques to match.

2.2 What is a thread? A short history lesson...

A thread "in essence" is a mechanism that transforms "torsion forces" into "axial forces". This property has been used for centuries to make presses and to transport fluids or powdered materials (the continuous thread turning changes torsion forces, displacing them axially or longitudinally).

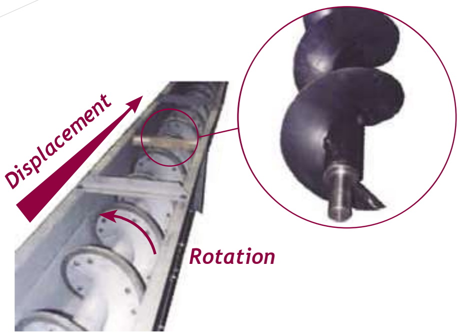


Figure 10
A continual thread is used to transport liquids and materials in many sectors.

The thread was invented around 400 b.c. by the Greek mathematician Archytas, the so-called "Father of mechanics". One of the first uses for a thread was in presses, to extract oil from olives and the juice from grapes. Since then, the design and use of threads have constantly evolved for different uses: from fluid transportation to fixings composed of nut and screw.

Regarding threads for joining parts, for many centuries "craftsmen" made "their" own nuts and screws according to "their" own criteria. Pitch, thread height and angle, helix angle, etc... differed according to manufacturer. At the height of the industrial revolution, arose the need to unite and standardise threads to ensure that fixings were compatible between different manufacturers and countries. In that way, it was easier to mass-produce, to reduce costs and to supply spare screws in case of repair.

It is important to point out that threads were the first elements to be standardised in different countries and in the second half of the twentieth century, a large number of different types of threads were standardised: ACME, ANT (American National Thread), Buttress, Whitworth, Whitworth Gas, Metric, etc... It is a curious history lesson to note that throughout the twentieth century, the countries with the most powerful economy imposed their thread for metals standards within their areas of influence.

Figure 11
Thread was used first to press fluids.

- In England and its ex colonies of Asia and Australia, the Whitworth standard was used with a 55o thread.
- In the United States, the American National Thread was standardised until 1948. In this year Whitworth and ANT threads united and became UNC (standard pitch thread for metals) and UNF (reduced pitch thread for metals), which have been and still are widely used in the United States, Canada, Central and South America.
- In "Continental" Europe, the German DIN standard was adopted.
- Japan, the second most important economy during the second half of the twentieth century, was fairly isolated with its JIS standards.

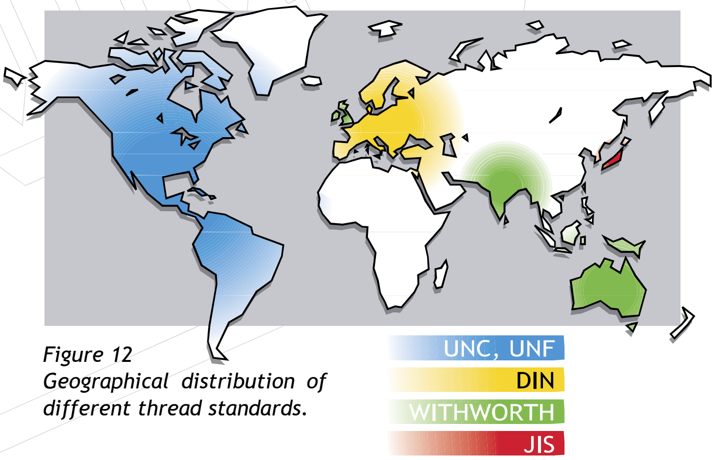


Figure 12
Geographical distribution of different thread standards.

This thread standards unification process, reached its peak at the end of the twentieth century with the creation of a single international standard for the screw industry, the ISO standard, which fortunately for Europe, used the DIN metric thread standard as its base. The change to threads according to ISO standard worldwide is occurring a lot faster than initially thought due to industrial globalisation. The reason for this is fairly evident: thread unification means a very large saving for companies that manufacture and sell globally. Standardisation permits assembling with the same screw types irrespective of place where assembly lines or suppliers are located. On the other hand, stocks are reduced and spare part logistics are easier.

2.3 Joints using screw and tapped nut

Joints between thread and screw can be divided into two large groups:

1. Joints where the female thread is made before assembly: (screws + nuts).
2. Joints with self-threading screws that cut female thread "during" assembly.

Undoubtedly, joints using nuts and screws have always been the most common, easy-to-use and even sometimes, the most economical in manual assembly short run production batches. However, this type of fixing has some critical technical disadvantages and it is difficult to robotize, making it an expensive solution not recommended for big industrial runs.

2.3.1 - Screw and pre-tapped nut fixing disadvantages:

1. ***Loosening caused by the assembly relaxation.*** *Joining two parts using a metric thread and pre-tapped nut, involves the following friction forces:*

- Friction between underside of screw head and cover part (detail A).
- Friction between screw threads and female thread (detail B). Both forces are responsible for maintaining tight fixing. In fact, the compression between the screw head and the material fixed reduces friction between the screw threads and screw (detail B) and the same axial force causes friction between the screw head and material base (detail A).

On one hand, by increasing the tightening torque, we achieve greater compression and greater fixing tightness by friction. On the other hand, high compression speeds up relaxation of the materials assembled (see Figure 14). This relaxation causes loss of clamping, , and consequently, reduction of the friction forces responsible of joining the parts. This situation gets worse when combined with one of the following factors:

- ***Joints exposed to vibrational movements.***
- ***Different thermal expansion coefficients of the different materials used in the joint.***
- ***Insufficient tightening torque. In most of the cases, the joint could become loose.***

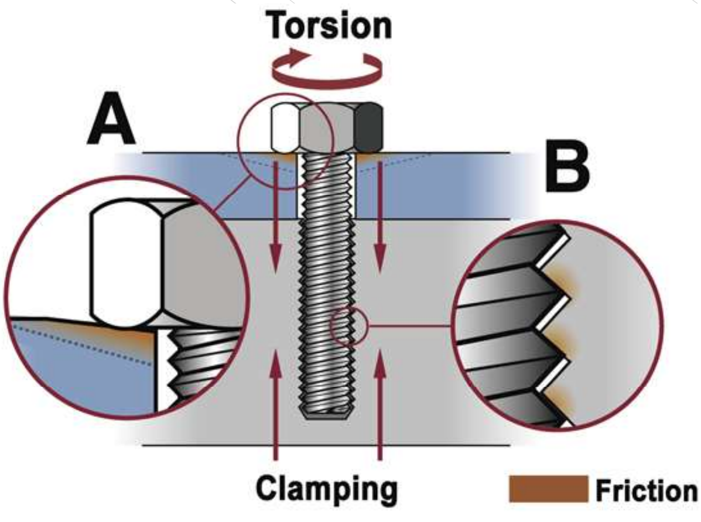


Figure 13
Friction forces detail:
(A) under the screw head.
(B) nut and screw threads.

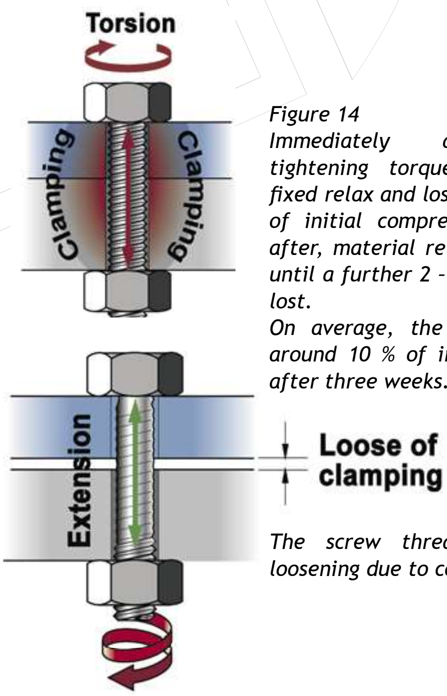


Figure 14
Immediately after applying tightening torque, the materials fixed relax and lose between 2 - 11% of initial compression. Some days after, material relaxation continues until a further 2 - 5% compression is lost.
On average, the parts fixed lose around 10 % of initial compression after three weeks.

The screw thread helix favours loosening due to compression loss.

Some common tricks to solve loosening problems caused by relaxation are the following:

- ***Increase tightening torque*** to indirectly increase friction force between male and female threads. However, this solution ***is not always possible*** as by increasing compression, it can ***damage the parts to fix***, cause even greater relaxation (as mentioned above), cause ***thread stripping*** in the assembly or even screw breaking.
- ***Tightening up the fixing a few hours after assembly.*** This is a non-viable and expensive solution in the majority of industrial uses. It neither guarantees against later loosening.
- ***Using lock washer to maintain compression after relaxation.*** This solution is ***difficult to automate*** and expensive because of the ***cost of the multiple assembly elements,*** and the ***time necessary to position the washers before insertion*** (although this can be reduced by using a screw with a preassembled washer).

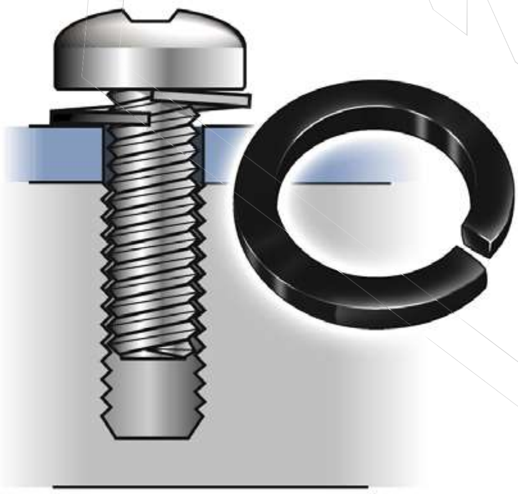
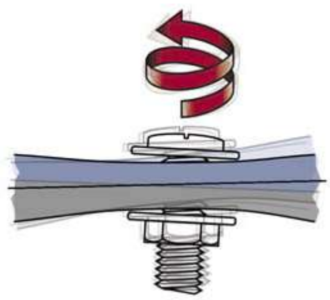


Figure 15
A joint using a metric threaded screw and a lock washer to maintain assembly compression.

2. ***Vibrational loosening.***

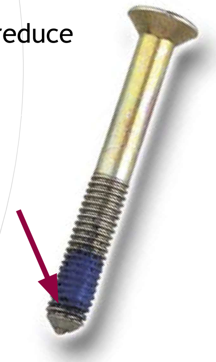
The problem is basically the same as the one described in the previous paragraph but caused by the effects of vibration (there are very few cases of completely static assemblies).



When ***the assembly is exposed to vibration***, the forces that act on **the screw thread**, **cause "unscrewing"** and consequently ***the assembly becomes loose***.

Moreover, temperature variations in different materials generate ***different degrees of thermal expansion*** in the screw and nut, this also ***causes loosening***.

Some of the solutions used to reduce vibrational loosening are:



- ***Applying adhesive to the thread,*** which is a very expensive and technically limited because of low temperature resistance. Also, it does not guarantee any resistance to loosening in later insertion and removal operations. Some chemical compositions can reach higher temperature resistance and reusable properties.
- ***Using friction brakes*** on the nut (for example DIN 985) or adding serrations under the screw head. Most common friction brakes on nuts are made in plastic and have also temperature limitations. The main problem of serrations under the head is that they become ineffective when there is no contact with the cover material.

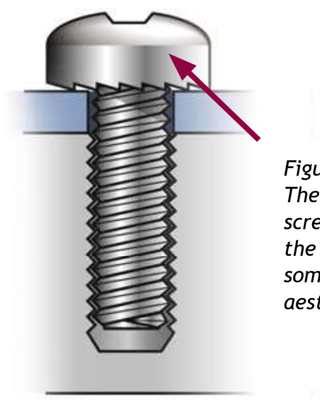


Figure 16
The serrations under the screw head can damage the part base, which in some cases can be an aesthetic impediment.

3. ***Difficult to automate and high assembly cost.***

Positioning the screw and nut automatically is not easy if we must achieve ***profitable, fault-free*** industrial assemblies. To solve this issue, it is common **to fix the nut by welding, riveting** or by using a ***metallic clip but these alternatives increase significantly the total assembly cost***. In some specific cases, the screw is fixed first to position and hold the parts to assembly (normally fairly heavy) that is later fixed with a nut (for example: car door assembly).

4. ***Cross threading during insertion:***

The helix angle of a metric thread screw is about to 2°. Minimal ***deviation*** from the vertical ***while inserting the screw*** in the female thread causes the first thread on the screw to align with the second or third thread on the female thread.

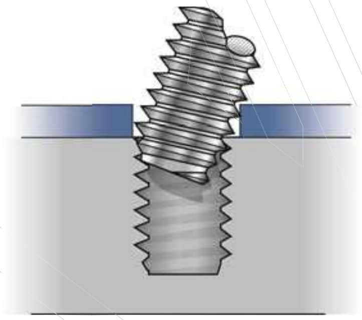


Figure 17
Cross threading due to misalignment of a metric thread on insertion.

In assemblies using pneumatic or electrical screwdrivers is very difficult to detect the defective alignment of threads, which could be consequently destroyed. To reduce this effect, specially in low accessibility holes, it is common to design a guide pivot on the screw point, although it increases purchasing price.

Figure 18
The guide point eases positioning for any type of thread.

2.4 Nut and screw assembly types

2.4.1 - Joining using a metric threaded screw and tapped hole

This type of joint is made by inserting a metric threaded screw into a tapped hole made by a die.

Clamping applied during tightening ***is transmitted from the surface of the screw to each of the flanges*** as can be seen in figure 19.

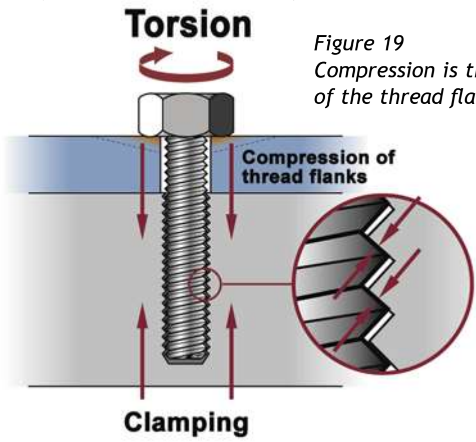


Figure 19
Compression is transported to each of the thread flanks.

The main reasons for using this type of fixing are its great popularity and versatility.

On the other hand, previously described disadvantages still happen: risk of vibrational loosening, compression loss, cross threading, etc... although the determining factor for replacing metric screws with a pre-threaded nut is the ***HIGH COST OF PRE ASSEMBLY OPERATIONS:*** hole preparation, tapping, burr removal and lubricating, thread inspection...

From our experience, the cost of creating an M4 thread is between € 6 and € 20/1000 parts when operations are carried out automatically. This cost is much more expensive than the screw itself.

Figure 20
In parts with a large number of holes, pre-operational costs become sky-high.

2.4.2 - Metric threaded screw and standard nut joint

A metric screw with hexagonal nut is the most known assembly for fixing parts with a through hole. Parts are joined by **clamping** through tightening torque **between the head of the screw and the nut** (see figure 21).

The main reasons for using them are its great popularity and versatility. On the other hand, this assembly has all the ***disadvantages*** we have previously mentioned, especially being ***difficult to automate and high labour cost***. In addition, assembly design is very limited as it is difficult to place the nut.

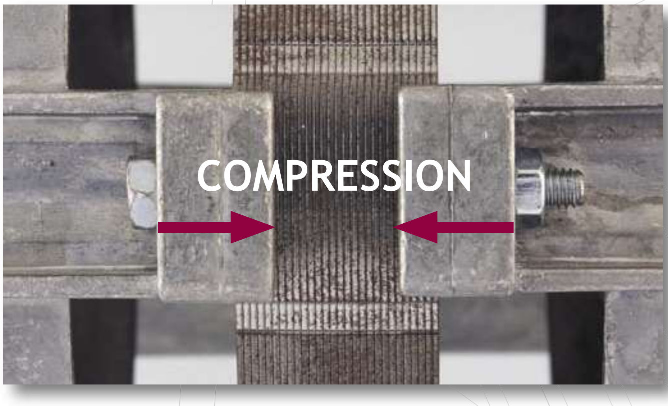


Figure 21
A typical nut and screw assembly.

2.4.3 - Caged nuts

Caged nuts enable assembling thin metal sheet using the metallic clip that surrounds the normally squared nut. With this system, we obtain a very robust fixing, although it has some ***disadvantages:***

- ***High operational cost*** for reinserting the nut: a ***special tool*** is needed to insert the nut and it cannot be automated.
- ***High components cost:*** caged nut + screws.

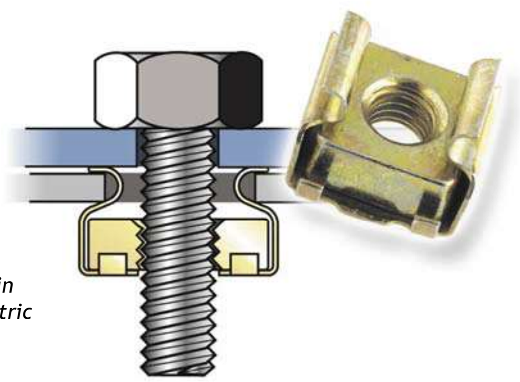


Figure 22
The caged nut is clipped to the thin sheet metal so we can insert a metric threaded screw.

2.4.4. Welded nut

The welded nut is one of the most common solutions to automate assembly of a metric threaded screw and nut.

Main reasons for use are:

- Simplifies manual or automatic inserting of the screw in the nut.
- Reduces assembly time (it is not necessary to place the nut).

Disadvantages are:

- ***High cost for the nut and welding operation.***
- ***It cannot be used on all thin sheet metal*** as it causes warping.

The nut is welded on four external points

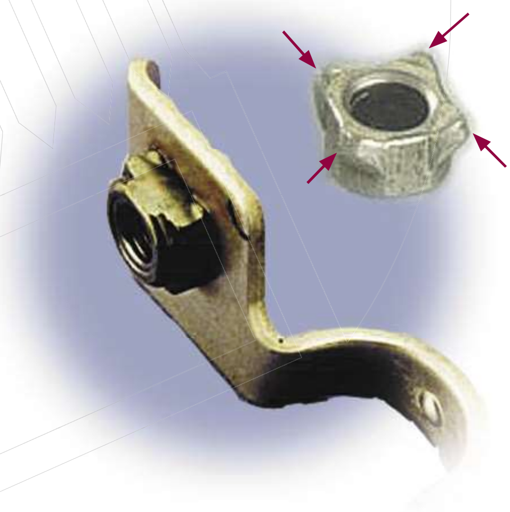


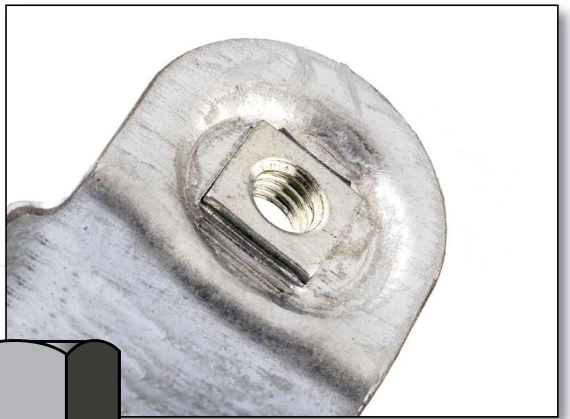
Figure 23
A nut welded to a metal part, it is welded on four external points.

2.4.5 - Self clinching nut.

A special nut is inserted by pressure into thin metal sheets. The nut has a fluting shape on the surface in contact with the base part that causes material displacement in the plate when inserted. This effect fixes the nut in the metal sheet.

The main advantage is faster insertion, so the operation can be automated into the same metal sheet stamping process, without using any special tools.

On the other hand, it is ***a relatively expensive part*** and offers ***low pull out resistance*** compared to the previously mentioned solutions.



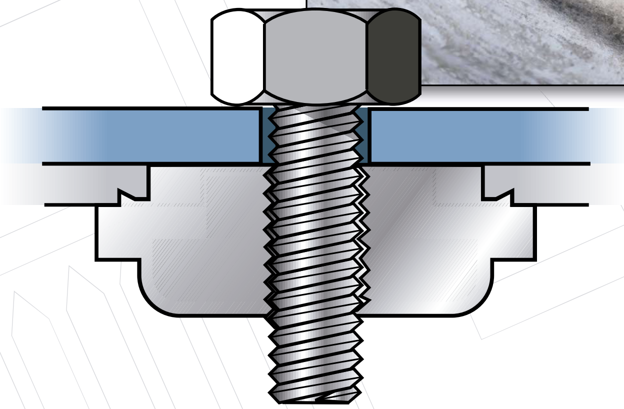


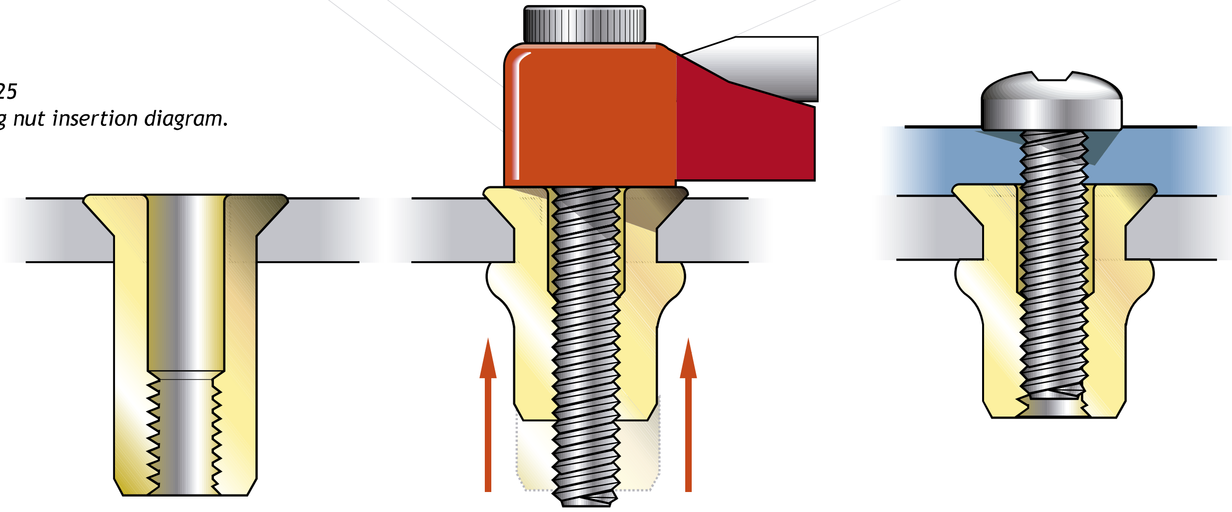
Figure 24
An example of self clinching nut.

2.4.6 - Riveting nut.

The riveting nut is the reusable version of a rivet. It has a cylindrical body made from ductile metal, with an internal metric thread. The part is riveted when the joined part is inserted and clamps the cylinder. (see figure 25).

The final results is a very reliable assembly with high resistance against axial as well as shearing forces. But it is difficult to automate and increases assembly costs because of long installation time and price of the riveting nut.

Figure 25
Riveting nut insertion diagram.



1. Riveting nut inserted. 2. Riveting. 3. Screw insertion.

3 JOINTS USING SELF-TAPPING SCREWS

In the previous chapter, we have reviewed several ways of fixing using a female thread, which is essentially an expensive solution for using in mass productions and somehow insecure as it tends to loose due to material relaxation, thermal expansion and vibrations.

Its industrial use has progressively being reduced in favour of self-threading screws, as they provide important assembly solutions for metals and notably reduce pre-assembly operation costs.

3.1 *What are self-tapping screws? Their evolution*

Self-tapping screws are known for their ability ***"to create their own thread"*** in the hole where they are inserted. The difference between metal threaded screws (screw with a metric thread) and self-tapping screws are:

1. ***Creating the female thread*** either by plastic deformation (self-tapping and Trilobular®) or by thread cutting (creating chips).

2. ***Surface hardness of the screw is often significantly higher than its core hardness:*** This higher hardness is necessary in order to ensure that the thread is capable of creating a female thread in the base part. The core hardness is kept lower in order to ensure an appropriate strength and elasticity.

3. "One way assembly" (clearly different from using screws and nuts, which need to be accessed from both sides of the parts to be fixed). They can be easily removed, are normally reusable and the assembly can be automated.

The first self-tapping screw designs appeared at the beginning of the 19th century. They were simple evolutionary steps from wood screws; they had nearly twice the pitch of a screw for metals and higher surface hardness. Initially they were used to fix central heating and metal sheet conducts for ventilation, given the difficulty to join them using a nut and screw. The designation ***"self-tapping screws"*** comes from their ability to tap their own thread while being inserted. This name is nowadays commonly used for many different thread types that create their own thread in steel, metal alloys and plastics. This "popularity" often generates some confusions that we try to clarify in this book and in our previous "Screws for plastics" handbook.

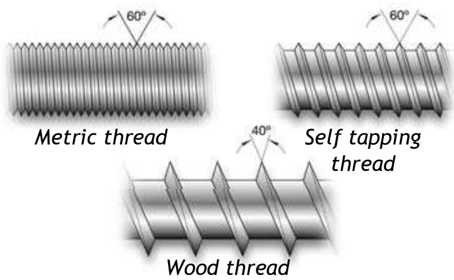


Figure 26
The differences in thread angle and pitch of a metric thread, self-tapping and wood screws.

As materials evolved and new metal alloys appeared in industrial processes, assemblies continued to use self-tapping screws. It was a versatile solution, "almost miraculous" regarding their endless possibilities and uses. But as the mechanical demands on joints increased, the need to use another type of self-tapping screw was necessary.

Self-tapping screws behave well with metal sheets of thicknesses between 0.3 and 0.8 times their nominal diameter, always and when the designed hole diameter is according to DIN 7970. But self-tapping screws are simply not suitable to fix on metals with thicknesses between 1 and 2 times the screw diameter.

The first self-tapping screw designed to solve this problem was the cutting thread screw: screw with a metric pitch and longitudinal cuts that creates the female thread by ripping out metal chips (the same as taps and dies).

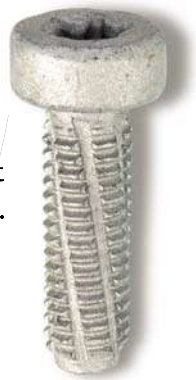


Figure 27
The uses the Cutting-thread screws are very specific.

In the 1960s, a new design of lobular self-tapping ***screws*** was developed that have shown to be the best solution up to the present day.

Although screws with other profiles have been developed, the ones that have demonstrated the best performance are ***TRILOBULAR® thread rolling screws*** the one, which enjoys the highest level of acceptance worldwide, are those manufactured according to ***TAPTITE®*** standards.

CELO

3.- Joints using self-Tapping screws

TRILOBULAR® Thread rolling screws have a thread profile similar to a metric thread but with a ***TRILOBULAR® section***. The point is particularly chamfered to allow a progressive growth of thread profile. These features ***allow the screw to make a very strong female thread with reduced threading torque:***

- Thread of the nut formed by material deformation.
- Deformation forces are only applied in three points, reducing friction.
- ***Progressive thread at the point ensures that the female thread is created with a low driving torque.***

(Further advantages of this type of screw are described in Chapter 4).

During the 1960s, the last great step forward in self-tapping screws was developed: **self-drilling screws**. This type of screw decisively contributes to assembly cost saving, as it makes the hole during installation, eliminating drilling operation. In addition, it ensures correct hole dimensioning according to the profile thickness that we want to drill[3].

Figure 28
A diagram of an assembly using a self-drilling screw.

At the beginning of the 21st century, evolution in self-tapping screw design continues, adapting to the needs of current industry.

The design of the ***REMFORM® F*** self-tapping screws has proven outstanding performance for light metal alloys such as ***aluminium and magnesium***. ***FASTITE® 2000™*** thread rolling screws have also shown their excellent performance to fix on very thin steel and aluminium metal sheets. (More information about FASTITE® 2000™ and REMFORM® 'F' in chapters six and seven respectively).

(3) *Regarding this point, it is important to know that for the same screw diameter up to five different drilling points can be used according to profile thickness.*
(4) *DIN 7500: self-tapping screws for ISO metric threads.*

3.2 *Advantages of TRILOBULAR® screws*

TRILOBULAR® screws refer to the three lobed screw family developed by REMINC which include:

REMINC CONTI

Research Engineering & Manufacturing

- TAPTITE 2000®
- TAPTITE 2000® "SP"™
- FASTITE® 2000™
- TAPTITE II®
- DUO-TAPTITE®
- TAPTITE® "CA"
- KLEERLOK®
- EXTRUDE-TITE®
- PLASTITE® 45
- PLASTITE® 48-2
- PLASTITE® 60
- PUSHTITE®
- POWERLOK®

These are some of the REMINC patented products.

3.2.1 - Introduction

TRILOBULAR® self-tapping screws were truly revolutionary in industry since their invention in the 1960s. There have been many designs that have "copied" the original TAPTITE® design.

Given their increased popularity, DIN and ISO norms specify the design of these type of screws. However, ***DIN*** or ***ISO*** standards ***do not define neither hole requirements nor thread tolerances applicable to this screw geometry.***

As there is no international standard, every "Non licensed" manufacturer establishes "its" TRILOBULAR® design, "its" Diameters and tolerances and "its" way to be progressively inserted. In fact, ***DIN 7500[4] standard does not define thread geometry,*** consequently, a four lobe screw, five lobe screw or any other shape can comply with the standard. The result is that, according to the screw manufacturer or even the tooling manufacturer, ***copies of TAPTITE® screws have very different behaviours in the same assembly.*** The main problems of these copies are the irregularity in behaviour between manufacturers or even between screws from the same batch.

Opposing this problem, ***TAPTITE® screws*** offer ***consistency*** as they are exclusively produced by licensed manufacturers that strictly follow REMINC[5] company standards. In addition, the tools used in manufacturing can only be supplied by authorised suppliers.

TRILOBULAR® screws are not limited to only one design. The experience of using more than 17 billion genuine TRILOBULAR® screws worldwide has allowed the licensing company REMINC ***to develop up to 35 models of TRILOBULAR® threads***, each of them designed to solve specific assembly problems.

Moreover, each TRILOBULAR® thread design has a series of technical details that ensure greater efficiency not only in manufacture but also during its working life, something that non-licensed manufacturers would find difficult to offer.

In summary, original TRILOBULAR® screws are the best alternative for your assembly needs as they offer:

- A wide range of solutions to reduce costs and improve the mechanical performance of the assembly.
- Validated uniform products.
- Worldwide product availability.

3.2.2 - Economic advantages

A) Assembly cost reduction

Currently, price reduction is the main objective of purchasing departments.

Particularly for screw parts, the strategy of continuous purchasing price reductions has proven not to be the most effective as the screw represents only 15% of total assembly operation costs. Many of our customers achieve important productivities by focussing on the reduction of the assembly costs. As an example, consider we achieve a 20% price reduction in the screw part (difficult to imagine!), this percentage applies on average to around 15% of the global cost that the screw price represents in the assembly; this means we would only achieve a 3% reduction. On the other hand, if we consider a reduction of 10% in the assembly operation costs (easily to get with a thread forming screw), we achieve a total reduction of 8,5%.

(5) *TRILOBULAR® screws have been developed and patented by the REMINC company.*

Figure 29
Only 15% of total assembly cost corresponds directly to the cost of the screw. TRILOBULAR® screws have been especially designed to significantly reduce the remaining 85%.

B) Unique design, unique validation and unique "worldwide" supply.

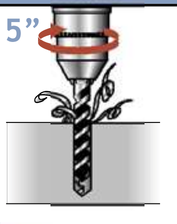
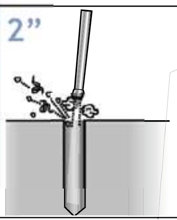
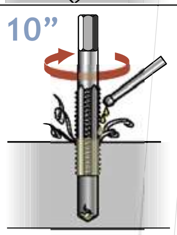
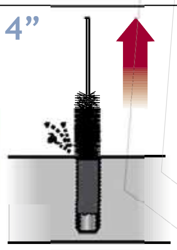
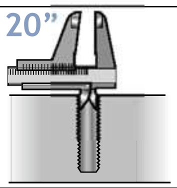
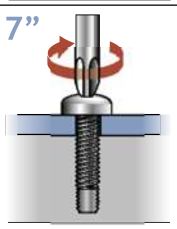
TRILOBULAR® screws have their own tolerance standards, ***which mean they can be supplied only by licensed manufacturers***, always guaranteeing their excellent performance. This is especially favourable for global companies which have similar product assembly lines in different countries, enabling them to get the homologated screw, following the same technical specifications, assuring the same performance and avoiding new validations.

Figure 30
Geographical distribution of the different TRILOBULAR® licensed manufacturers.

CELO

3.- Joints using self-Tapping screws

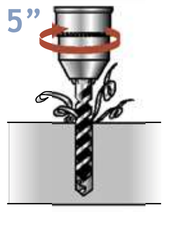
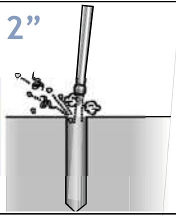
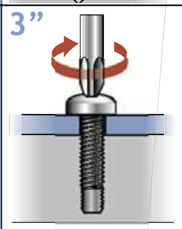
The following table details direct and indirect costs (based upon 2005 data) and the risks associated to each assembly operation using a **METRIC SCREW** and tapped nut.

	OPERATION TIME IN SECONDS	DIRECTLY ASSOCIATED COSTS	INDIRECTLY ASSOCIATED COSTS	ASSOCIATED RISKS	ESTIMATED UNIT COST
DRILLING	5” 	-Drilling time -Drill bit consumption -Machine set up time -Bit changing time	-Supply and stock of drill bits -Drill bit identification and control -Drilling machine maintenance	-Wrong hole diameter -Drill bit breaking	0,04 €
CHIPS REMOVAL	2” 	-Blowing time	-Equipment maintenance	-Inefficient chips cleaning	0,016 €
LUBRICATING AND TAPPING	10” 	-Lubrication time -Lubricant consumption -Tapping time -Machine set up time	-Supply and stock of lubricants -Supply and stock of taps -Tapping machine maintenance	-Badly tapped thread -Tap breaking, hole obstruction	0,08 €
LUBRICANT AND CHIPS CLEANING	4” 	-Lubricant and chips removal time -Solvent consumption	-Supply and stock of solvents -Equipment maintenance	-Inefficient chips cleaning	0,032 €
THREAD VERIFICATION	20” 	-Verification time -Purchasing gauges, calibrating and measuring equipment -Incorrect thread reprocessing	-Measurement tool calibration and maintenance -Measurement tool identification and control	-Verifying mistakes	0,16 €
SCREW INSERTION	7” 	-Screw cost -Washer cost - to avoid loosening -Screw insertion time -Time used to place washers, nuts...	-Supply and stock of fixing elements -Screwdriver maintenance	-Tolerance between female thread and screw causes loosening in parts exposed to vibration -Cross threading	Screw: 0,0066 € Washer: 0,0025 € Time: 0,056 € **Total: 0,065 €**

Total: 0,3933 €/unit

The total cost of assembly operations **using a metric thread is 0,3933 €.** Consider that cost of the associated risks are not covered by this table.

The following table details direct and indirect costs (according to 2005 data) and the risks associated to each assembly operation with a **TRILOBULAR® SCREW**.

	OPERATION TIME IN SECONDS	DIRECTLY ASSOCIATED COSTS	INDIRECTLY ASSOCIATED COSTS	ASSOCIATED RISKS	ESTIMATED UNIT COST
DRILLING	5” 	–Drilling time –Drill bit consumption –Machine set up time –Bit changing time	–Supply and stock of drill bits –Drill bit identification and control –Drilling machine maintenance	–Wrong hole diameter –Drill bit breaking	0,04 €
CHIPS REMOVAL	2” 	–Blowing time	–Equipment maintenance	–Inefficient chips cleaning	0,016 €
SCREW INSERTION	3” 	–Screw cost –Screw insertion time	–Supply and stock of screws –Screwdriver maintenance		Screw: 0,0112 € Time: 0,04 € **Total: 0,0512 €**

Total: 0,1072 €/unit

In the example given, the TAPTITE II® screw is priced at 0.0046 €/unit more than a metric screw (70% higher purchasing price!!!). However, the COST OF PRE-ASSEMBLY OPERATIONS with the TAPTITE® screw is 0.286 €/unit less, this means a 73% saving.

The time needed is five times less, which means an INCREASE IN PRODUCTIVITY: more parts manufactured in the same time.

The mechanical advantages of the assembly using TRILOBULAR® thread forming screws are difficult to achieve with a metric screw and tapped nut (these factors are explained in detail in the following section).

3.- Joints using self-Tapping screws

3.2.2 - Mechanical Advantages

A) Low threading torque

This is one of the most outstanding features of a TRILOBULAR® screw: the ***TRILOBULAR® geometry*** of the thread applies pressure intermittently during insertion, ***reducing friction*** and the force necessary to create the female thread in the hole (Threading torque).

TAPTITE II® SCREW BEHAVIOUR, DIN 7981 AND CUSTOMER REFERENCE

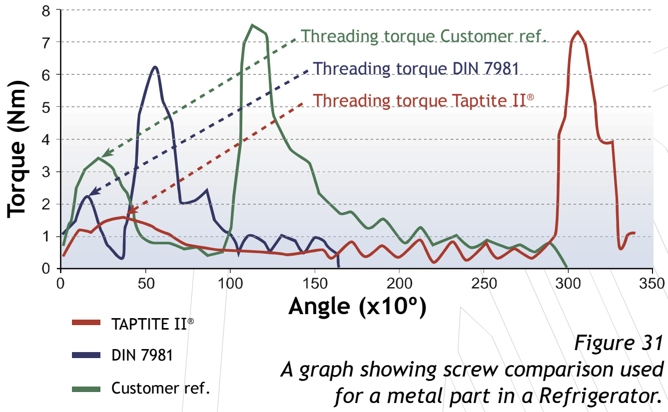


Figure 31
A graph showing screw comparison used for a metal part in a Refrigerator.

Screw	Threading torque	Failure torque
TAPTITE II® M4,5x10 mm	1,65	7,32
DIN 7981 4,8x10 mm	2,10	6,29
Client M5x10 mm	3,43	7,33

B) Pull out resistance.

TRILOBULAR® screws create the female thread in the hole by ***material lamination***, without chips creation. This fundamental property ***guarantees a high pull out resistance:***

- Once the screw is introduced, the material displaced during insertion flows to fill the space between threads and lobes: the screw body becomes tightly surrounded by material.

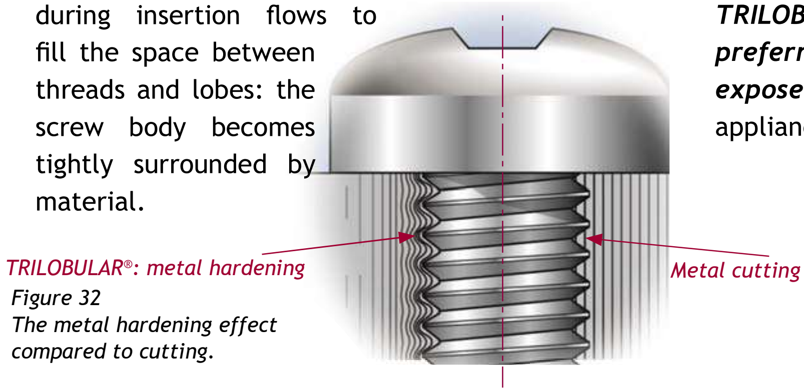


Figure 32
The metal hardening effect compared to cutting.

C) Resistance to vibrational loosening

A recent study in the United States revealed that 23% of problems in cars sold were due to screw loosening, of which 12% belonged to new cars.

One of the most significant advantages offered by ***TRILOBULAR® screws is the resistance to vibrational loosening:***

- On one hand, TRILOBULAR® screws create their own female thread in the hole that ***eliminating the tolerance between the screw and female thread.***
- On the other, the material displaced flows to surround the screw body blocking the screw throughout its length.

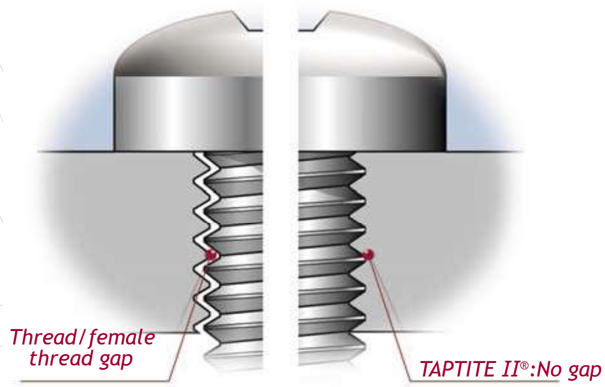


Figure 33
A TRILOBULAR® screw creates tolerance free thread.

As a consequence of the above mentioned effects, we can ensure ***that vibrational loosening resistance for TRILOBULAR® screws is optimum***, even improving the results obtained with screws using elastic washers or adhesive patches.

TRILOBULAR® screws are, undoubtedly, those preferred by engineers when developing assemblies exposed to vibration (automotive industry, household appliances, printing machinery).

D) Eliminates the possibility of cross threading.

TRILOBULAR® screws eliminate the Cross Threading effect as the holes where they are inserted do not have a female thread.

In the case of automated assembly lines, ***their effectiveness is 100%***, without the need to design screws with pilot points which increases screw cost.

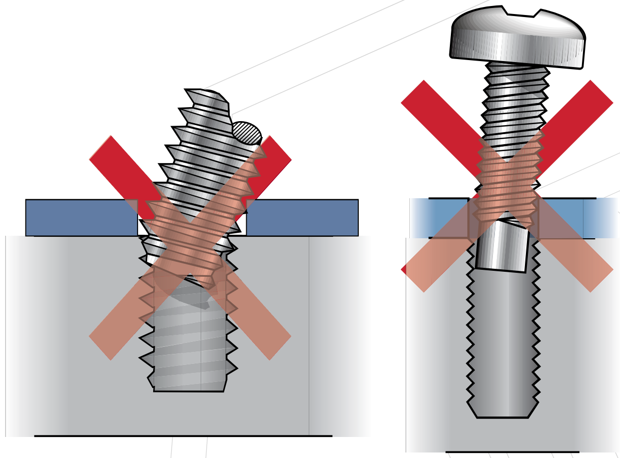


Figure 34
Misalignment from the vertical, it causes screw threads to mismatch with the female thread. In automated assembly lines, machinery cannot detect it and it continues applying force until they destroy the female thread.

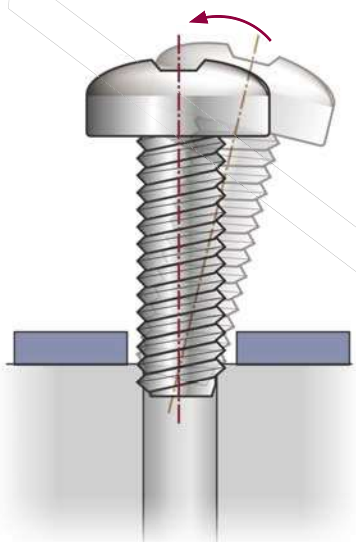


Figure 35
TRILOBULAR®self-tapping screws create their own thread in the hole and eliminate the possibility of damaging screw threads.

E) Can be used in contaminated holes.

High surface hardness of ***TRILOBULAR® screws*** creates a female thread even in holes ***contaminated with*** paint, welding splash, etc. In particular assembly lines, it has increased productivity and has provided cost and time savings, as there's no need to remove these contaminants previously.

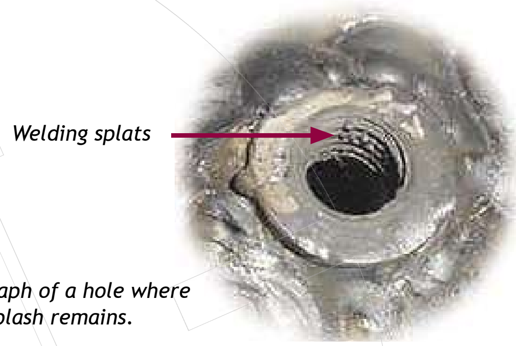


Figure 36
A photograph of a hole where welding splash remains.

F) Creation of nut by lamination, no chips produced.

Compared to other self-tapping screws, ***TRILOBULAR® screws create the nut by material deformation without producing chips:*** this is fundamental in electronic applications where it is necessary to avoid metallic chips as they can cause short circuits.

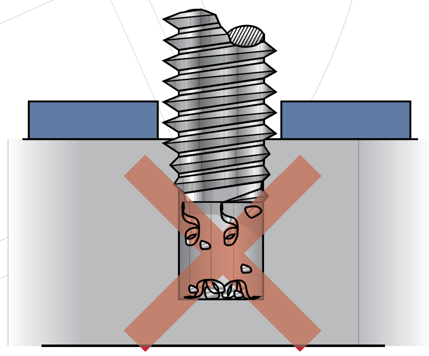


Figure 37
Chips created during female thread forming.

G) Standard screw compatibility

The female threads created by ***TRILOBULAR® screws*** have the ***same dimensions*** as ***metric nuts*** so, if for any reason the ***TRILOBULAR®*** screw is lost, ***metric threaded screw can be used instead.*** It makes it very versatile for applications that could be manipulated by the end user.

4 TAPTITE II®

The TAPTITE II® thread is undoubtedly the most popular of the TRILOBULAR® thread family, containing more than 30 different thread types.

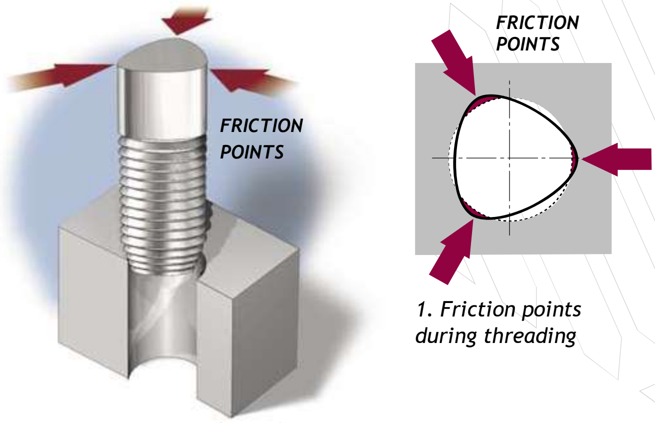
TAPTITE II® application provides with very important cost savings by the elimination of ***pre-assembly operations*** (described in Chapter 3 of this manual) additionally offering ***advantageous solutions*** for ***different assembly problems*** that commonly exist in the assembly industry.

4.1 *TAPTITE II® technical advantages*

4.1.1 - TRILOBULAR® thread section

Compared to all other existing designs, the TAPTITE II® TRILOBULAR® thread is renowned for:

- ***Low threading torque***. The three thread lobes apply pressure intermittently, which enables insertion with the minimum effort; that is why it is most appropriate for ***insertion in deep holes with ergonomic torques***.

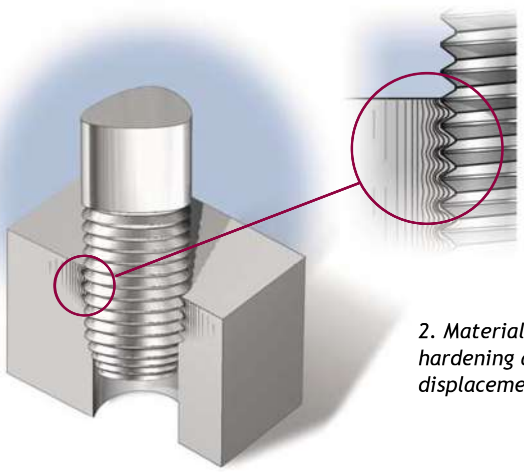


1. Friction points during threading

- ***Internal thread deformation, without creating chips***.

  - Avoids the risk of short-circuiting electrical and electronic appliances.

  - Highly resistant female thread because it does not cut but displaces material.



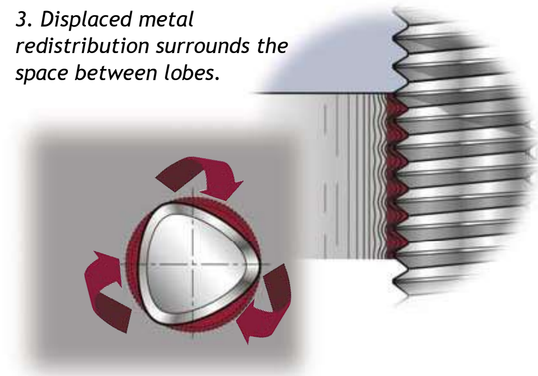
2. Material hardening and displacement.

- Once the screw is inserted, the displaced ***metal flows to enclose the screw body***, providing a greater metal surface and screw contact:

  - Greater pull out resistance.

  - Greater resistance to vibrational loosening.

3. Displaced metal redistribution surrounds the space between lobes.



- The hole has no pre-shaped female thread, the screw itself creates the internal thread; eliminating cross threading problems.

4.1.2. Thread angle and pitch are the same as a metric thread.

- The thread created in the metal allows re-using with metric screws.

4.1.3. Progressive thread insertion:

- Low initial threading torque.

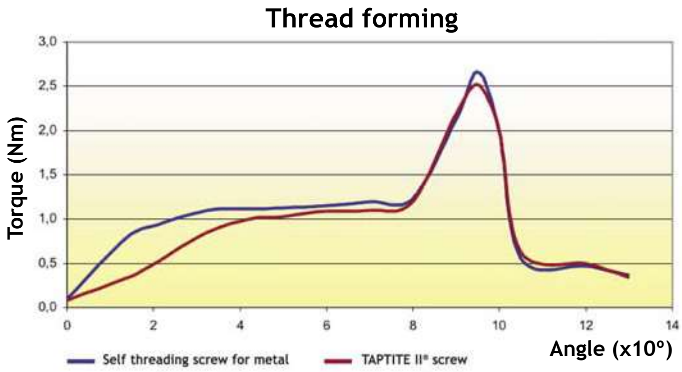


Figure 38
TAPTITE II® insertion curve compared to a self-tapping screw.

4.2 TAPTITE II® applications

The TAPTITE II® screw is widely used for metal parts assembly in a large variety of products. Its use has provided great savings in assembly costs. We can find them in motors, irons, pans, rear view mirrors, refrigerators, etc... Additionally, in many cases, they have solved apparently difficult assembly problems, **at a global cost significantly cheaper than other existing solutions**.

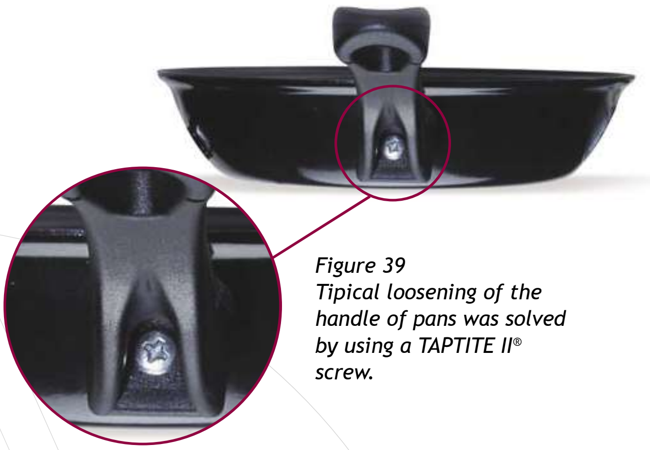
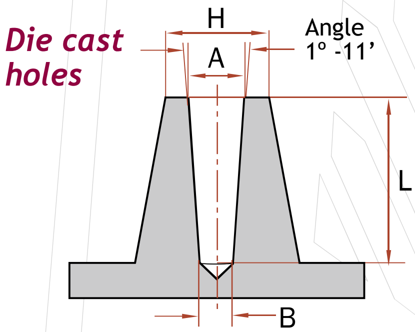
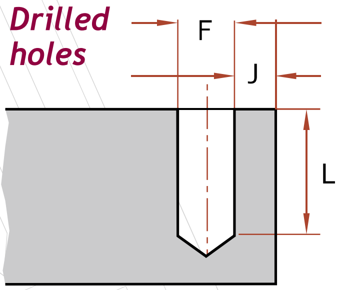


Figure 39
Tipical loosening of the handle of pans was solved by using a TAPTITE II® screw.

4.3 TAPTITE II® technical data

TAPTITE II® hole diameters in light alloys.





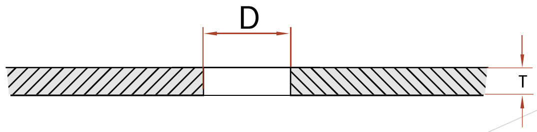
Hole diameter	H_{min}	A	L	B
M2	3,3	1,8-1,9	4	1,7-1,8
M2,5	4,2	2,3-2,4	5	2,2-2,3
M3	5,0	2,8-2,9	6	2,7-2,8
M3,5	5,8	3,2-3,3	7	3,1-3,2
M4	6,6	3,7-3,8	8	3,5-3,6
M4,5	7,5	4,2-4,3	9	4,0-4,1
M5	8,3	4,7-4,8	10	4,5-4,6
M6	10,0	5,6-5,7	12	5,4-5,5
M8	13,3	7,6-7,7	16	7,3-7,4

Hole diameter	F	J	L
M2	1,8	1,0	4
M2,5	2,3	1,2	5
M3	2,8	1,3	6
M3,5	3,2	1,6	7
M4	3,6	1,8	8
M4,5	4,1	2,0	9
M5	4,6	2,1	10
M6	5,5	2,6	12
M8	7,4	3,3	16

Measurements in mm.

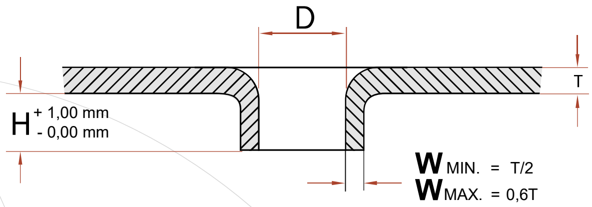
4.- TAPTITE II®

Taptite II® screws in steel metal sheet.



Screw diameter	Sheet thickness (T)	Hole diameter (D)	Drive torque (Nm)
M2	1,0	1,8	0,5
	2,0	1,8	0,7
	2,5	1,8	1,2
M2,5	1,0	2,3	0,7
	2,0	2,3	1,0
	2,5	2,3	1,5
M3	1,0	2,7	1,0
	2,0	2,8	1,4
	3,0	2,8	1,6
M3,5	2,0	3,2	1,3
	3,0	3,2	2,0
	4,0	3,2	2,7
M4	2,0	3,6	1,8
	3,0	3,7	3,3
	4,0	3,7	4,3
M4,5	2,5	4,2	2,4
	3,5	4,1	3,9
	5,0	4,1	4,6
M5	2,5	4,6	2,8
	3,5	4,6	6,0
	5,0	4,6	7,0
M6	3,0	5,4	5,0
	4,5	5,5	10,0
	6,0	5,5	10,0
M8	4,0	7,3	20,0
	6,0	7,4	28,0
	8,0	7,4	30,0

Taptite II® in steel metal sheet with extruded hole.



Screw diameter	Hole diameter (D)	Sheet thickness (T)	Flange height (H)
M2	1,8	0,5-0,9	0,5-0,6
		0,7-1,3	0,4-0,5
M2,5	2,2	0,6-1,1	0,6-0,7
		1,1-1,6	0,5-0,7
M3	2,7	0,8-1,4	0,7-0,9
		1,4-2,0	0,6-0,8
M3,5	3,2	0,9-1,6	0,8-1,0
		1,6-2,3	0,7-0,9
M4	3,6	1,0-1,8	0,9-1,2
		1,8-2,6	0,8-1,1
M4,5	4,1	1,1-2,0	1,1-1,3
		2,0-2,9	1,0-1,2
M5	4,5	1,3-2,3	1,2-1,5
		2,3-3,3	1,1-1,3
M6	5,4	1,5-2,7	1,4-1,7
		2,7-3,9	1,3-1,6
M8	7,3	2,0-3,6	1,9-2,3
		3,6-5,2	1,7-2,1

Measurements in mm.
These values have been obtained experimentally with hex washer head screws, zinc platted, lubricated and inserted in laboratory conditions.
The data given is only valid for these conditions and any change (metal sheet thickness, hole diameter) can mean a variation in results.

5 TAPTITE 2000®

TAPTITE 2000® was designed ***to combine the capabilities of previous TAPTITE® designs*** and simultaneously, offer a design that could be accepted worldwide.

TAPTITE II® design was widely used in the seventies by most of the manufacturers in North America. It was not until the eighties, when Europe started to massively use TRILOBULAR® screws in their assemblies. At that time, they adopted the latest TRILOBULAR® screws generation called DUO-TAPTITE®. This screw incorporates TRILOBULAR® section at the point for easy thread forming and a "less TRILOBULAR®" body section to increase pull out resistance (particularly interesting in aluminium and zamak assemblies) (see 5.1.1).

The dual designs in Europe and the United States continued throughout the eighties and nineties. At the end of the nineties, the largest multinational companies (in automotive, electronic, household appliance industries, etc.) demanded the use of standardised elements in any part of the world and its design, combine a high pull out resistance and low drive torque (ergonomic assembly). REMINC developed a new thread design that took the best technical advantages of both designs, TAPTITE II® and DUO-TAPTITE®, which replaced them and could be used as a global standard: that is how ***the TRILOBULAR® TAPTITE 2000® was born***.

5.1 *TAPTITE 2000® technical advantages:*

5.1.1 - Double TRILOBULAR® sections

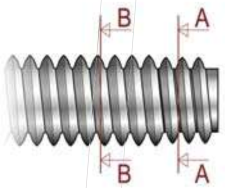
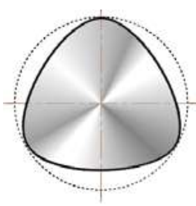


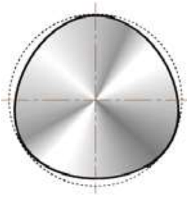
Figure 40
Section A: TRILOBULAR® thread at screw point.
Section B: TRILOBULAR® screw body.



Section A

Section A. The screw point with a higher TRILOBULAR® grade:

- ***Reduces thread-forming torque.*** The drive torque of the TAPTITE 2000® is 10% less than TAPTITE II®, this feature makes it perfect for large diameter screw assembly (M > 8) ***with ergonomic drive torque***.



Section B

Section B. Section of the body with lower TRILOBULAR® grade to increase ***surface contact between the screw and the female thread***.

- ***Improves pull out resistance***

5.1.2 - Radius Profile™ Thread, *which increases the contact surface between the screw and the thread created, (figure 41: D>d) contributing to greater thread locking:*

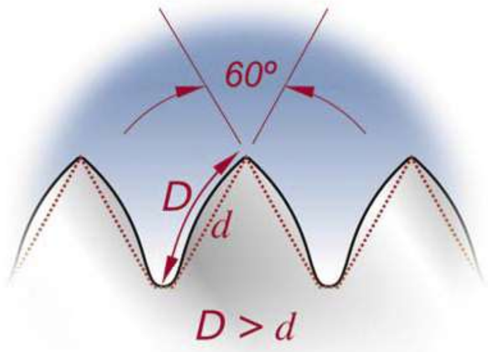


Figure 41
Radius Profile™ Thread of TAPTITE 2000® fastener compared to metric screw.

- ***Greater resistance to vibrational loosening***
- ***Increases stripping torque***.
- ***Better safety ratio,*** reducing drive torque and increasing stripping torque, we obtain a wider safety margin during insertion.
- Allows assembly with high torque, ***providing the assembly with higher clamping***.

5.1.3 - Pilot threads on the point

- Better ***axial alignment*** in the hole, the screw aligns itself vertically.

5.2 TAPTITE 2000® applications

The TAPTITE 2000® screw is very appropriate for assembling steel and light alloys, where low drive torque and high resistance to pull out forces are required. In addition, the design of the screw point eases alignment in the hole and reduces insertion time.

For structural uses with high pull out resistance requirements, there are different versions of the TAPTITE 2000® with similar qualities to 8.8 and 10.9 metric screws: the latter achieved induction heat treatment CORFLEX®-I.

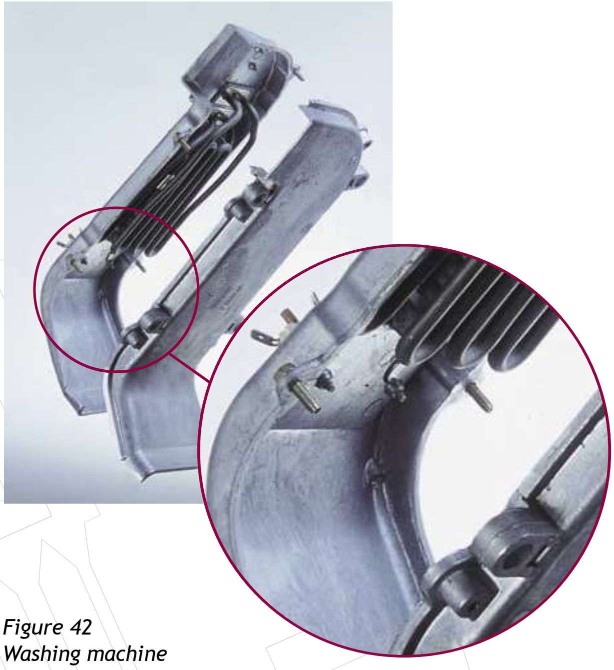
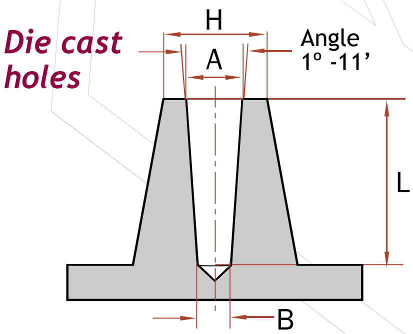
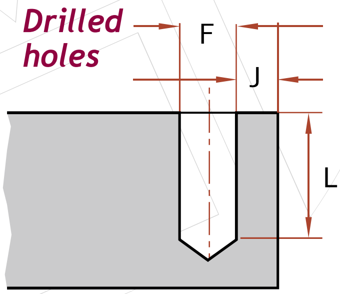


Figure 42
Washing machine resistance; the clamping transmitted through the tightening torque with the TAPTITE 2000® screw keeps the resistance airtight.

5.3 TAPTITE 2000® technical data

TAPTITE 2000® hole diameter in light alloys



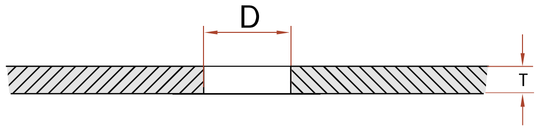


Hole diameter	H_{min}	A	L	B
M2	3,3	1,8-1,9	4	1,7-1,8
M2,5	4,2	2,3-2,4	5	2,2-2,3
M3	5,0	2,8-2,9	6	2,7-2,8
M3,5	5,8	3,2-3,3	7	3,1-3,2
M4	6,6	3,7-3,8	8	3,5-3,6
M5	8,3	4,7-4,8	10	4,5-4,6
M6	10,0	5,6-5,7	12	5,4-5,5
M8	13,3	7,6-7,7	16	7,3-7,4

Hole diameter	F	J	L
M2	1,8	1,0	4
M2,5	2,3	1,2	5
M3	2,8	1,3	6
M3,5	3,2	1,6	7
M4	3,7	1,8	8
M5	4,6	2,1	10
M6	5,5	2,6	12
M8	7,4	3,3	16

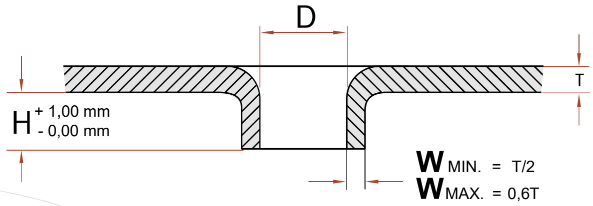
Measurements in mm.

TAPTITE 2000® Screws in steel metal sheet



Hole diameter	Aluminium sheet		Steel sheet	
	Thickness (T)	Diameter (D)	Thickness (T)	Diameter (D)
M2,5	0,9-1,5	2,27	1,5-2,1	2,30
M3	1,1-1,7	2,74	1,7-2,7	2,77
M3,5	1,4-2,0	3,19	2,0-2,9	3,23
M4	1,4-2,4	3,64	2,4-3,3	3,68
M4,5	1,7-2,7	4,11	2,7-3,9	4,16
M5	2,1-2,9	4,58	2,9-4,4	4,64
M6	2,4-3,6	5,48	3,6-4,9	5,55
M8	3,1-4,9	7,35	4,6-6,9	7,43

TAPTITE 2000® Screws in steel metal sheet with extruded hole.



Screw diameter	Sheet thickness (T)	Hole diameter (D)	Flange height (H)
M2,5	0,5-0,69	2,22	1,00
	0,7-0,99	2,23	1,00
	1,0-1,49	2,24	1,00
M3	0,5-0,69	2,70	1,20
	0,7-0,99	2,71	1,20
	1,0-1,49	2,72	1,20
M4	0,7-0,99	3,59	1,35
	1,0-1,49	3,61	1,35
	1,5-2,49	3,64	1,50
M5	1,0-1,49	4,56	1,55
	1,5-2,49	4,59	1,80
	2,5-3,0	4,63	1,90
M6	1,0-1,49	5,45	1,80
	1,5-2,49	5,48	2,30
	2,5-3,0	5,51	2,40
M8	1,0-1,49	7,27	2,10
	1,5-2,49	7,31	2,95
	2,5-3,0	7,35	3,20

Measurements in mm.

These values have been obtained experimentally with hex washer head screws, zinc platted , lubricated and inserted in laboratory conditions. The data given is only valid for these conditions and any change (metal sheet thickness, hole diameter) can mean a variation in results.

6 FASTITE® 2000™

Every new product development has to take into serious consideration the need to ensure a design that can be manufactured at a very competitive cost. Many times, the use of lighter and thinner materials have been limited by the problems of fixing parts on thin metal sheets of steel or aluminium

A. On one hand, the self-tapping screws (principally simple self-tapping or TRILOBULAR® screws) have had ***serious failings when it comes to assembling*** very thin metal sheets.

B. ***Other assembly elements*** such as a welded nut, caged nuts, self clinching or riveted nuts ***are expensive to install and cause loosening and clamping loss problems.*** Furthermore, welding, gluing or even riveting cannot be easily removed to recycle components (as mentioned earlier in Chapter 3 of this manual).

Problems caused by self-tapping screws in thin metal sheet:

The concept of thin metal sheet is always relative to the screw that is going to be used: we understand ***thin metal sheet*** as being ***less than one third of nominal screw diameter***. In the case of using self-tapping screws, the minimum metal sheet thickness ***must be equal to screw pitch***. If we use a 2.2 millimetre diameter screw (0.8 In assemblies with self-tapping screws in thin plates, the following problems could occur:

1. ***Thread stripping during assembly:***

- Very small difference between threading and stripping torque (yellow area in figure 43). Even a small adjustment in screwdriver calibration could cause a large number of incidents.

TYPICAL INSERTION CURVE FOR DIN 7981 IN THIN METAL SHEET

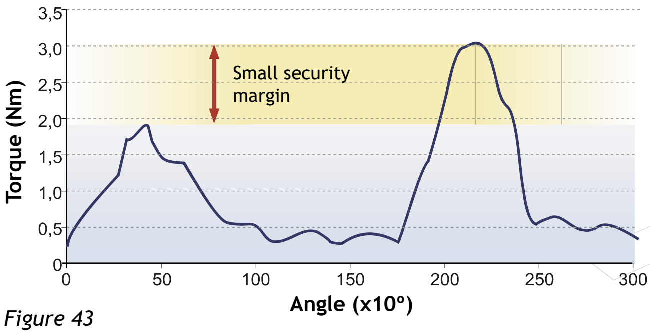


Figure 43
The difference between the screw forming torque and stripping torque is only 1Nm.

- Small variations in screw and/or hole dimensions, may cause stripping thread on many situations, with the same assembly torque.

2. Due to ***the poor quality of the female thread*** created in the metal sheet, the assembly has poor ***mechanical capabilities***:

- ***Low resistance to pull out forces.***
- ***Easily becomes loose,*** worsened by movement/vibration/dilatations.
- ***Low clamping:*** the assembly torque applied is the minimum to avoid thread stripping.
- Often, the non threaded part under the head of the screw is larger than the thickness of the total assembled parts, leaving the screw clipped into metal sheet without applying clamping force.

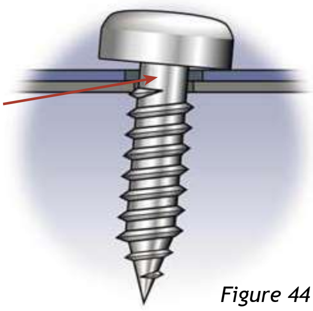


Figure 44

This problem is partially solved by using regular thread forming screws similar to TAPTITE II®. However, the screws only work correctly when we previously create an extrusion in the metal sheet, (see the chapter dedicated to TAPTITE II®).

(6) *DIN 7975: Tapping Screws Connections*
(7) *Safety ratio: coefficient between stripping torque and drive torque.*

6.1 FASTITE® 2000™ technical advantages

The FASTITE® 2000TM screw was explicitly conceived to solve assembly problems on ***thin metal sheets***. Its thread design had to comply with the following factors:

- Allows assembly with high torques value to guarantee clamping without thread stripping or damaging of the sheet.
- Ensure high pull out resistance.
- Avoids loosening under vibrations.

6.1.1 - TRILOBULAR® shape thread, the same as TAPTITE 2000®:

- ***Low drive torque***.

6.1.2 - Radius Profile™ Thread, the same design as TAPTITE 2000®

- Greater contact area between screw thread and the female thread created: ***increases resistance to traction and vibrational loosening***.

6.1.3 - Double thread

- The ***stripping torque increases by approximately 50%*** compared to a single thread screw.
- ***Twin double thread positions the screw perpendicular to the metal sheet*** and ensures the screw head rests evenly on the base part.
- A greater number of threads are in contact with the female thread created, therefore increasing pull out resistance.

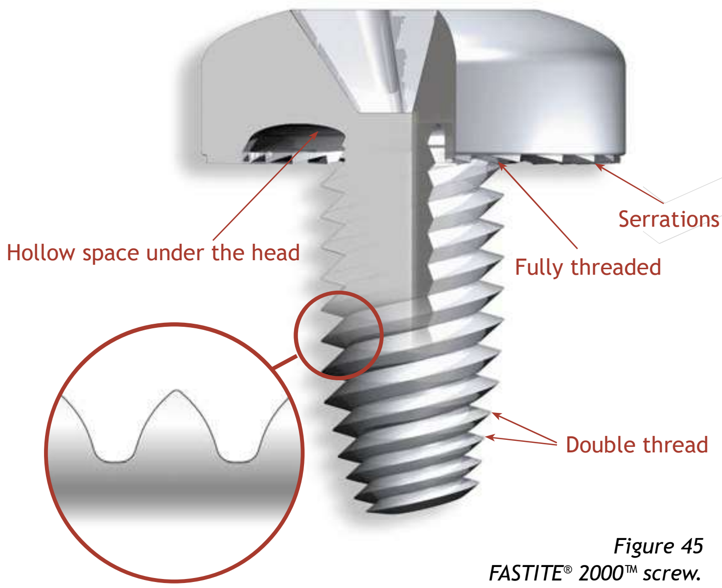


Figure 45
FASTITE® 2000™ screw.

6.1.4 Self-extruding point

- The ***extrusion created*** during insertion increases the effective ***assembly length*** (see figure 46).

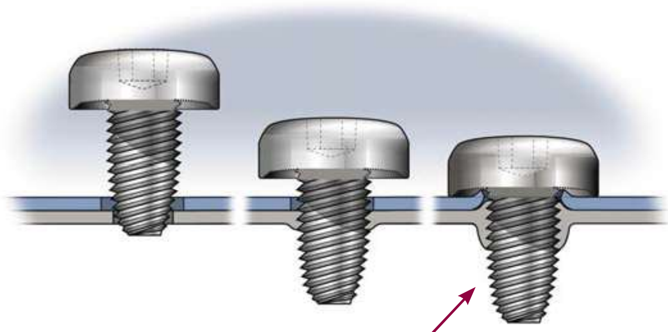


Figure 46
Extrusion created by the FASTITE® 2000™ screw.

6.1.5 Serrations under the head (optional)

- Increases stripping torque.
- Improves resistance to loosening.

6.1.6 Screw thread up to the base of the head

- Allows assembly in very thin metal sheet without ***the screw becoming clipped***.

6.1.7 Hollow ring under the head (optional)

- Absorbs ***the metal sheet extruded outwards***: this is very important for applications where the head must keep contact with the assembled part (electrical contact for example).

6.1.8 Optional "cut off" point

- This type of point allows a fast piercing of the metal sheet when there is no pre-made hole (such as the FASTITE® PG used to fix hinges on sandwich panels for garage doors) (see 6.4).

6.- FASTITE® 2000™

6.2 FASTITE® 2000™ applications

The FASTITE® 2000™ screw is mainly used in either thin aluminium or steel metal sheet assemblies. Its use has allowed significant improvements in mechanical resistance of the assemblies in a wide variety of products such as PC Boards, lighting, household appliances, garage doors, etc. Moreover, FASTITE® 2000™ could replace other more expensive fastening systems and, very especially, more costly at installation. FASTITE® 2000™ has proven a very successful performance when reducing assembly costs, and contribution to achieve a lower production cost.

FASTITE® 2000™ screw head can be headed with "scrapping serrations" capable of removing the paint from the metal sheet base allowing excellent electrical contact. In addition, a hollow ring can be added under the head where the upper part of the extruded material is allocated to ensure a perfect contact to the base.

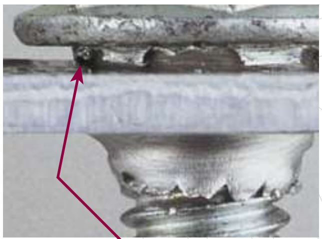
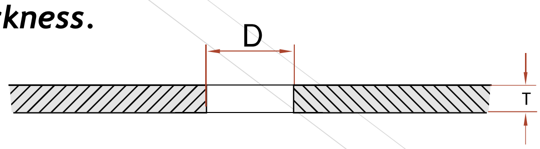


Figure 47
Material extruded upwards by the FASTITE® 2000™ screw.

6.3 FASTITE® 2000™ technical data

Recommended hole Diameter for steel and aluminium metal sheet, according to sheet thickness.



Screw diameter / T	Aluminium sheet		Steel sheet			
	1,5	2,5	0,5	1,0	1,5	2,0
M3	2,1	2,2	2,0	2,1	2,2	-
M4	2,6	2,7	2,5	2,7	2,8	2,9
M5	3,3	3,4	-	3,5	3,6	3,7

Steel metal sheet hardness: 125-150 HV

Measurements in mm.

These values have been obtained experimentally with FASTITE® 2000™ screws, pan headed and zinc plated inserted in laboratory conditions. The data given is only valid for these conditions and any change (metal sheet thickness, hole diameter) can mean a variation in results.

6.4 FASTITE® PG

The FASTITE® PG has been developed to solve assembly problems in hinged joints on sandwich panels. Due to the reduced metal sheet thickness used in panel sandwich (0.7-1.2 millimetre), the use of conventional self-tapping screws does not offer sufficient guarantees regarding pull out resistance or vibrational loosening. Many screws would become loose after the door was opened and closed for about 100 to 300 times. By this time, the hinge would not actuate and the door would not open.

FASTITE® PG permits a higher tightening torque without stripping the metal sheet and would not become loose at least after more than 1000 cycles.

Figure 48
The hinged assembly on a sandwich panel using a FASTITE® PG screw.

FASTITE® PG combines the technical advantages of the FASTITE® 2000™ screw with the addition of a "cut off" point which pierces the metal sheet and avoids pre-drilling.

Figure 49
Extrusion created by a FASTITE® PG with no previous hole.

CELO

7 REMFORM® ‘F’

REMFORM® ‘F’ screw is another step in the evolution of REMFORM® thread (hard plastics assembly) which was developed to solve specific assembly problems:

- Assembling on magnesium. Currently, this metal is frequently used in the automotive and electronic industry for its lightness and mechanical properties. However, the low plasticity of this metal does not allow to achieve a strong female thread.
- Open holes in aluminium assembly. In aluminium profiling it is quite common to assembly parts with an open hole, called a C-shaped hole (see figure 50). Due to the longitudinal opening, the contact between male and female thread is significantly reduced compared to a closed hole.
- Demoulded holes (largely conical). Insertion in this type of hole is difficult because a high drive torque is necessary, which can even cause the screw to block.

In all of the above cases, the usage of traditional self-tapping screws does not offer sufficient guarantees; ***low pull out resistance and low clamping***, especially when they are exposed to bending movements.

Figure 50
Open hole view (C-shaped hole).

7.1 *REMFORM® ‘F’ technical advantages*

REMFORM® ‘F’ design was based on the successfully proven REMFORM® design for very hard plastics . As the thread engagement in metals is lower than in plastics, the pitch of REMFORM® ‘F’ was significantly reduced to achieve more “holding” points. Therefore, the design of this thread was not defined by DIN 7500, as it does not create an internal metric pitched thread.

7.1.1 - Asymmetrical thread profile, the same as a REMFORM® screw:

The load flange is nearly perpendicular to pullout force (12.5° angle).

- ***Higher pull out resistance***.
- ***Greater clamping transmission.*** Transmitted upwards by tightening torque to each of the flanges.
- ***Reduces tension in the metal during insertion*** and avoids blocking in the housing.
- ***Guide flange*** on the parabolic profile that eases metal displacement during insertion.
- ***Cleaner female thread***, that ***allows re-using***.
- ***Chips free insertion***.

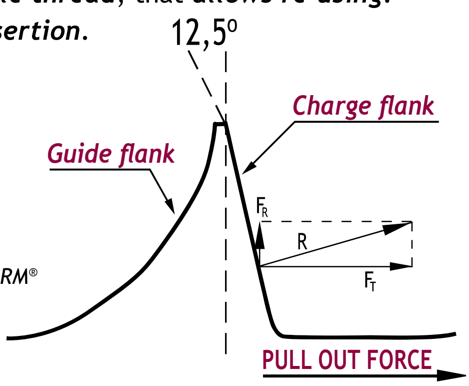


Figure 51
A view of the REMFORM® thread asymmetry.

7.1.2 - Reduced pitch, increases screw contact points with the metal base.

- ***More resistant to vibrational loosening***.
- ***Better resistance to pull out***.
- ***Increases stripping torque***.

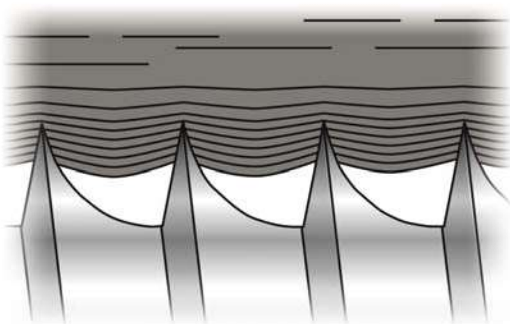


Figure 52
Metal distribution during insertion with a REMFORM® ‘F’ screw.

7.2 REMFORM® 'F' applications

The high pull out resistance offered by the load flange of the REMFORM® 'F' makes it ideal for uses that are continually exposed to pull out forces (handles for aluminium windows or assemblies where the hole is not completely closed as internal mechanisms made of injected aluminium).

Although it is not the objective of this manual, we believe that it is important to notice that REMFORM® 'F' has also proven and excellent behaviour with thermo sed plastics.

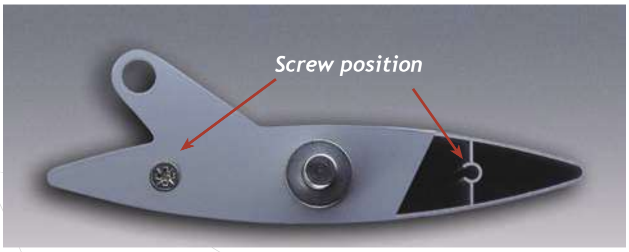
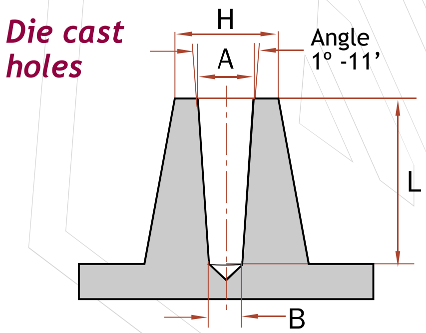
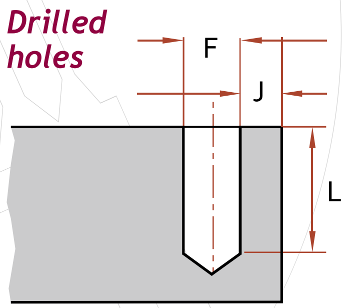


Figure 53
An aluminium Venetian blind cover assembly with REMFORM® 'F' screw.

7.3 REMFORM® 'F' technical data

REMFORM® 'F' hole diameters in light alloys





Screw	Hold Diameter		L	H
	A	B		
2	1,8-1,9	1,7-1,8	5,0	3,3
2,5	2,3-2,4	2,2-2,3	6,3	4,2
3	2,8-2,9	2,6-2,7	7,5	5,0
3,5	3,2-3,3	3,0-3,1	8,7	5,8
4	3,6-3,7	3,4-3,5	10,0	6,6
5	4,6-4,7	4,3-4,4	12,5	8,3
6	5,5-5,6	5,2-5,3	15,0	10,0
8	7,4-7,5	7,0-7,1	20,0	13,3

Screw	F	L	J
2	1,8-1,9	5,0	1,4
2,5	2,2-2,3	6,3	1,8
3	2,7-2,8	7,5	2,2
3,5	3,1-3,2	8,7	2,5
4	3,5-3,6	10,0	2,9
5	4,4-4,5	12,5	3,6
6	5,3-5,4	15,0	4,2
8	7,1-7,2	20,0	5,3

Measurements in mm.

These values have been obtained experimentally with pan headed, zinc plated screws and inserted in laboratory conditions. The data given is only valid for these conditions and any change (metal sheet thickness, hole diameter) can mean a variation in results.

8 TAPTITE® CA

The TAPTITE® CA is based on the TAPTITE II® or TAPTITE 2000® designs, but incorporates a sharp point to solve hole alignment and access problems. Therefore, their performance in the assembly is the same of the design of the TAPTITE II® or TAPTITE 2000® thread.

8.1 *TAPTITE® CA technical advantages*

8.1.1 - TRILOBULAR® section thread, the same as TAPTITE II® or TAPTITE 2000® screws, the thread and geometry contributes to an improvement in performance and assembly cost savings:

- ***Low threading torque***.
- ***Female thread created by material deformation***; chips free.
- ***High assembly safety ratio***.
- Tolerance free female thread, ***better pull out and loosening resistance (vibrational, dilating...)***.

8.1.2 CA point type, specifically designed for:

- ***Aligning the screw in assemblies with off-centred holes or holes difficult to access.***
- ***Low initial drive torque*** allows progressive insertion.

8.2 *TAPTITE® CA applications*

All TAPTITE® CA uses benefit from the specially designed point properties:

- Assemblies with off-centre holes, where the hole centre of the cover does not align with the hole where the screw has to be inserted.
- Deep holes or holes difficult to access, where the upper part hampers screw alignment: the TAPTITE® CA effectively aligns itself vertically consequently saving assembly time.
- Assemblies where it is necessary to pierce fabric, gasket, cardboard, carpet, etc..., which allows insertion without needing to make a hole in the material.

The progressive shape of the point also makes it an ideal solution for "cleaning-while-inserting" holes contaminated with paint, welding splash, etc...

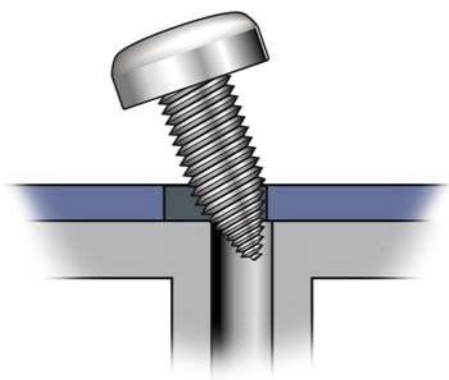


Figure 54
The CA point allows insertion in off-centre holes.

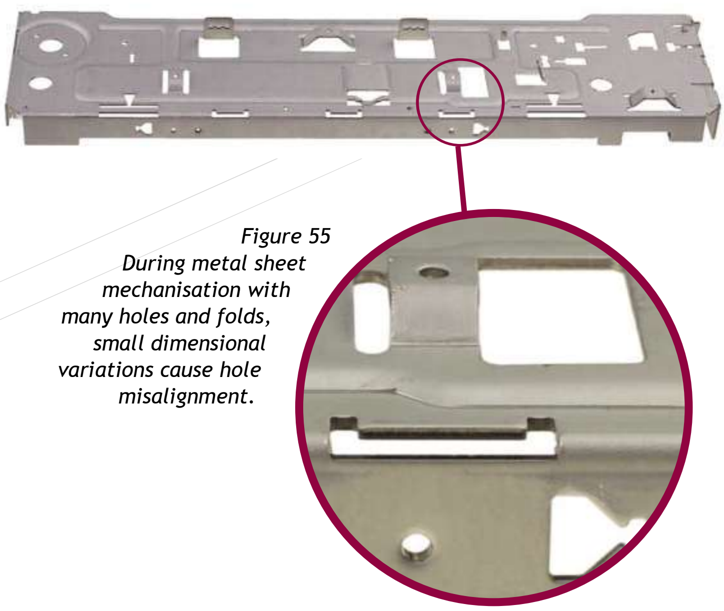


Figure 55
During metal sheet mechanisation with many holes and folds, small dimensional variations cause hole misalignment.

9 EXTRUDE-TITE®

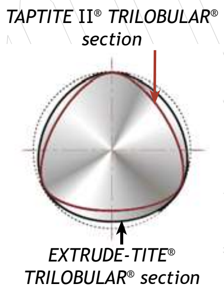
The design concept of this type of thread was developed in the 1980's to solve pull out resistance and thread stripping problems in thin metal sheets. Although the new FASTITE® 2000™ screw design has improved the performance of EXTRUDE-TITE® (especially in small diameters), this type of thread is still widely used in some specific applications.

9.1 *EXTRUDE-TITE® technical advantages*

As we have already described with the FASTITE® 2000TM screw (Chapter 6) one of the main assembly problems that design engineers have to face is the fixing on very thin metal sheets. TAPTITE II® was often a good solution when the hole was extruded in the metal sheet. However, it was not sufficient for some demanding applications with higher pull out or high assembly torque requirements. EXTRUDE-TITE® was the evolution of TAPTITE II® that solves these problems.

9.1.1 Thread with less lobulation than a TAPTITE II®: EXTRUDE-TITE® was designed with smaller trilobularity which offers the following advantages:

- Greater contact between screw and female thread in the metal sheet, ***increasing pull out and stripping resistance***.
- A high quality female thread is formed by displacing the metal.



9.1.2 Easy alignment in the hole, due to CA type point design. The screw can be inserted into the hole with an angle of up to 24° from the axis.

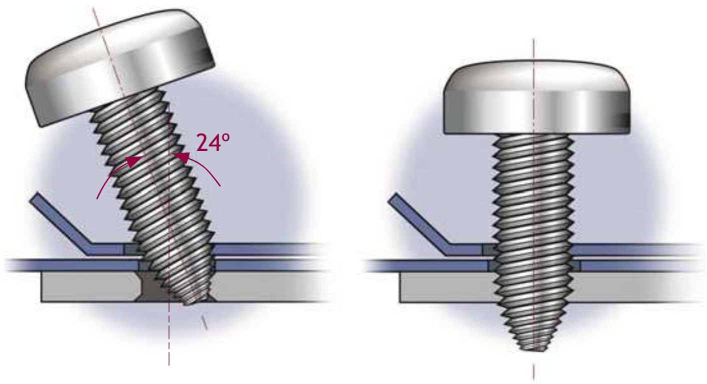


Figure 56
Screw self-alignment, the screw looks for a vertical position, even though the upper sheets are misaligned.

9.2 *EXTRUDE-TITE® applications*

Assembly of thin metal steel or aluminium sheets in grounding wires connections, household appliances, lighting, automotive industry.

EXTRUDE-TITE® thread design creates a metric thread on the steel sheet. This condition is essential in some applications (ie: grounding wires connection in household appliances), that require a metric thread by specification or to ensure that it can be replaced by a standard screw if the original one is lost. Also, the metric pitch ensures a higher clamping than FASTITE® 2000TM twin thread so a better electrical contact is achieved.

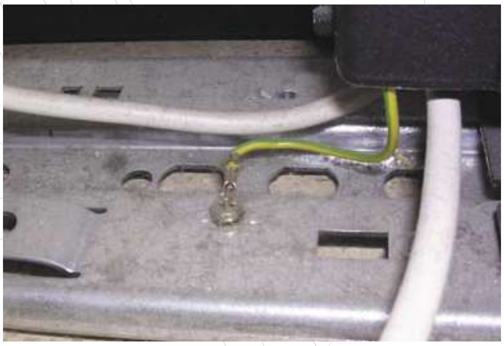


Figure 57
A grounding wire connection in a Refrigerator.

10 POWERLOK®

POWERLOK® TRILOBULAR® screw was designed to solve loosening problems in assemblies with nut or a tapped hole. This problem mainly appears when the assembly is exposed to severe vibration or dilating and contraction cycles.

There are two well known solutions to avoid these loosening problems: application of adhesive patches in the screw thread or usage of friction elements.

- Adhesive patches are not reliable in applications exposed to high temperature and loses their locking properties in future insertion and removal operations.
- The usage of friction elements, such as serrations under the screw head, is only effective as long as the assembly is under compression. When there is some relaxation, even with minimal separation, there is no friction and the assembly becomes loose with time.

POWERLOK® TRILOBULAR® screw is the only one with a locking concept: its thread design causes locking throughout its length, independently of the thread materials and the temperatures the assembly will be exposed to.

10.1 POWERLOK® technical advantages

10.1.1 - A 30º thread angle overlapped to the standard 60º thread angle:

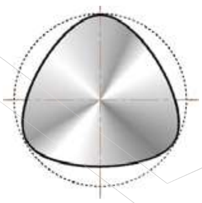
- The tip of the 30º thread cleaves the nut, avoiding any thread clearance, and ensuring a high friction between screw and female threads (see figure 58).
- ***Continuous locking action*** allows re-using without affecting its locking capabilities.

10.1.2 - Optimised thread tolerances:

- This contributes to strong blocking in the female thread.

10.1.3 - TRILOBULAR® section thread, along with its thread design, favours female thread material displacement, creating a new thread that has no clearance.

- Independently blocks female thread tolerance.



A Section

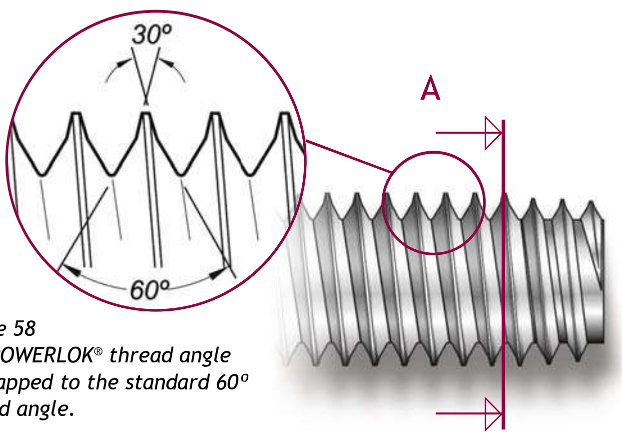


Figure 58
The POWERLOK® thread angle overlapped to the standard 60º thread angle.

10.2 POWERLOK® applications

The POWERLOK® screw is used ***to eliminate loosening problems*** in those applications where the hole already ***has a female thread***. For example:

- Glasses: the opening and closing movement of the arm causes loosening and the screw to fall free.
- Washing machine legs: the POWERLOK® screw is capable of withstanding vibrations caused during spinning.

It is also ideal when the assembly must be exposed to high temperatures. No other locking system, adhesive patches or plastic brakes are capable of withstanding these conditions.

11 F.A.Q'.S FREQUENTLY ASKED QUESTIONS REGARDING ASSEMBLING A METALS

11.1 Can I use a TAPTITE II® or TAPTITE 2000® screws with a nut or with an already tapped hole?

It is not recommended because as TAPTITE® screws create a new female thread, there is the possibility that the screw threads overlap over the female thread, destroying the nut and affecting the mechanical properties of the assembly.

11.2 Is it possible to manufacture a TAPTITE® screw class 10.9?

Screw type according to UNE-EN-ISO 898 is exclusively for metric screws, whose hardness properties are uniform throughout thread section. TAPTITE® screws must create their own thread in a hole, therefore surface hardness should be higher. It means the hardness is not uniform throughout all its section.

However, although UNE-EN-ISO 898 standard does not apply, we could say that a TAPTITE® II screw has a mechanical behaviour equivalent to an 8.8 metric class screw.

In applications where 8.8 class screws are required in soft metals, CELO recommends CORFLEX® heat treated TAPTITE® screws, which provide high durability combining good bending toughness and resistance to high load stresses cycles. It's been specially designed for very high demanding requirements assemblies in aluminium and light alloys.

11.3 Can I use a stainless steel TRILOBULAR® thread rolling screw on a stainless steel metal sheet?

Definitely NO. A Thread forming screw must have a significant higher hardness than the material where the female thread would be formed. Otherwise, the male thread would be damaged resulting in an assembly of poor quality. In this case, stainless steel screws have the same hardness as the material where we wish to make the thread.

Heat treated steel screws hardness is higher than stainless steel, which means they canthread this type of material. However, we recommend to consult our technical department to confirm.

11.4 Can I use a metric screw gauge (go - no go) to verify a TAPTITE® thread?

NO, as the TRILOBULAR® section of the thread and its dimensions are different from those of a metric thread.

11.5 Is a TAPTITE® TRILOBULAR® screw reusable?

YES, the TAPTITE® screw can be inserted and removed without damaging the initial female thread, provided the screw is properly aligned to the hole. Moreover, in case of lost, the TAPTITE® screw can be substituted by a metric screw as the female thread created is geometrically identical to a metric female thread.

11.6 What are the main differences between a TAPTITE® TRILOBULAR® screw and "similar" Trilobular screws?

There can be "many" differences, but there are three effects that clearly differentiate TAPTITE® screws from those that look the same: ***lower drive torque***, ***higher fail torque*** (drive torque/breaking), and ***greater homogenous functionality*** between parts from the same batch or different production batches.

11.7 What screw type can I use to hold a circuit board in place on a metallic base?

The clamping transmitted by the tightening torque is lost with time due to the plastic properties of the circuit board. This phenomenon is unavoidable, but CELO, has a technical good solution without increasing assembly cost: a TAPTITE II® screw with a flexible spring washer standard product TT22T:

- The flexible washer ensures constant clamping during product life.
- Easy assembly even in areas with difficult accessibility.
- Free rotation washer that avoids damaging the circuit during insertion.
- Increases resistance to vibrational loosening or temperature changes.

A metric thread version is also available for use with pre-tapped holes (ref. M22T).

11.8 *What is the "best" thread design for fixing on metals?*

This is a good question... that we prefer to answer after gathering some samples from you and doing different tests in our laboratory.

As we have seen throughout this manual, there are a large variety of uses for metals and a multitude of thread designs, which make it difficult to determine the best solution. From our experience, we can intuitively choose two or three viable options, as shown in the table below, but only by carrying out physical tests and analyse the different performances, we can we offer the optimum solution.

That's the reason why CELO laboratory, where our technicians carry out threading tests; thread stripping tests, pull out resistance tests, etc..., is at our customer's disposal. Only after testing they will recommend which type of thread best adjusts to the assembly needs.

In the following table, one dot (•) indicates an adequate screw and two dots (••) indicate the optimum screw for each assembly feature.

	TAPTITE II®	TAPTITE 2000®	FASTITE® 2000™	REMFORM® 'F'	TAPTITE® CA	EXTRUDE-TITE®	POWERLOK®
Steel metal sheet	••	••					
Zamac and aluminium	••	••		•			
Thin sheet (steel and aluminium)			••			•	
Magnesium				••			
High pull out resistance	•	••		••			
Low drive torque	••	••			•	•	
Vibrational loosening	••	••	••	••	••	••	••
C-shaped hole				••			
Misaligned holes			••		••	••	
Contaminated holes (paint, welding splash)	•	•			•	•	
Threaded holes							••
High clamping	•	••	•	••	•	•	

• Suitable
•• Optimum

12 EXAMPLES OF SOLUTIONS FOR METAL FIXING PROBLEMS

12.1 *Handles and hinges for aluminium windows.*

A well-known manufacturer of handles and hinges for aluminium windows was visited by a CELO technical sales representative. One of their star products were handles for oscillating opening system windows made from zamak, which needed to be assembled on to the handle base and at the same time were fixed to the window frame.

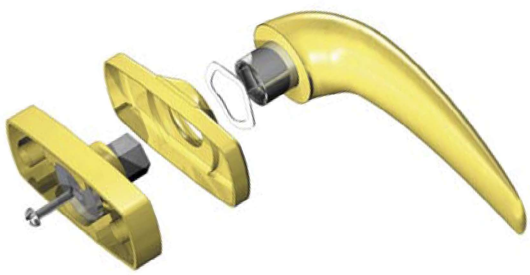
The system used by the customer was:

1. Producing the handle by die casting zamak.
2. Creating the female thread by tapping.
3. Cleaning the part from lubricating oils and zamak chips removal.
4. Painting the part
5. Assembling the part with a metric thread and wave spring washer.

The process has no problems in production, although there were some critical points:

- If the cleaning process was not perfect and some lubricant still remained, the part could not be painted correctly, creating a serious problem regarding the finished look of the products. To reduce this effect, they employed one full-time worker to improve part cleaning. This affected production cost and also became a bottleneck in the production line.
- The tapped hole had to be covered during the painting process to avoid the paint filling the nut thread.
- It was very important not to forget to place the wave spring washer, as it prevented (but not totally) the screw from loosening when opening and closing.

In the past, CELO proposed to use a TAPTITE II® thread rolling screw for this use in order to save assembly costs of tapping, cleaning, hole covering, and spring washer. But the answer was always the same: "our system works", we have no problems and we cannot take the risk to change. Also, the price of a TAPTITE® screw is significantly higher than my actual cost for a metric screw, and this will not help me to achieve my objective of purchasing price reduction ".



The opportunity came up the day the bottleneck in the cleaning process did not allow a production increase to cover a very large order from an important customer.

Remembering the comments that CELO sales engineers had made to the Technical Department about "some special screws that made their own thread", the production manager decided to contact us.

The advantages using a TAPTITE II® screw were evident and easy to understand:

I. TAPTITE II® screw creates internal thread directly into the die cast holes, eliminating tapping operations.
II. Elimination of cleaning away operation: there were no particles or lubricants to remove. The painting process was always clean.
III. It was not necessary to cover the hole as the contamination by paint did not prevent the TAPTITE II® screw to form a correct female thread.
IV. The TAPTITE II® screw had a very good performance during insertion, despite the conical shaped hole: drive torque was 0.65 Nm and stripping torque 4.80 Nm. Therefore, the assembly safety ratio was more than satisfactory, which meant that there were no problems in calibrating the screwdrivers on the assembly line.
V. Nobody had even thought of it, but the TRILOBULAR® shape of the TAPTITE II® screw was so resistant to loosening, that using the washer on the handle to avoid loosening.

The production manager summarized the importance of the advantages achieved:

1. ***Increased production without investment, moreover, two posts were saved.***
2. ***An improvement in final product quality: Finished product had a regular good appearance. Pull out and vibration resistance properties were also improved.***
3. ***A SUBSTANTIAL TOTAL COST REDUCTION FOR THE ASSEMBLY DESPITE THE TAPTITE II® SCREW BEING MORE EXPENSIVE THAN THE EQUIVALENT METRIC SCREW.***

12.2 A "noise" in the car

A car manufacturer contacted our technical department to solve a problem: one of the internal components in the front doors for their best-selling model was fixed into place using six metric screws inserted into six welded nuts. ***The nuts were welded before painting the door but some welding splashes contaminated the nut thread during the process.***

Due to this, the necessary driving torque to insert the metric screw was so high that the welding spots on the nut broke and felt inside the door panel. If it was the first nut, the line operator could removed it (not without some difficulty). If it was the sixth nut, it was more difficult to repair and sometimes it was felt inside the door. The problems found would often low down the production line, with a significant reduction in productivity. The following additional problems were found.

- The after-sales service received many complaints from clients about "noises" from inside the door (made by the nuts rattling around).
- Some nuts missing caused a lack of clamping in the assembly, to ensure the good working of the electrical components inside the door (electric power window system, speakers, central locking).

Some of the car manufacturer's technicians were aware of the properties of TRILOBULAR® screws; they remembered that there was a screw that "cleaned the paint from inside the female thread". CELO application engineers confirmed that a TRILOBULAR® design called KLEERLOK® was capable of removing paint or welding splashes while installed from the female thread.

CELO engineers ran a large series of tests to ensure that the solution offered was correct. As the final report was handed to our customers' Technical department, one of our engineers asked if there was any special reason to have such and expensive assembly.

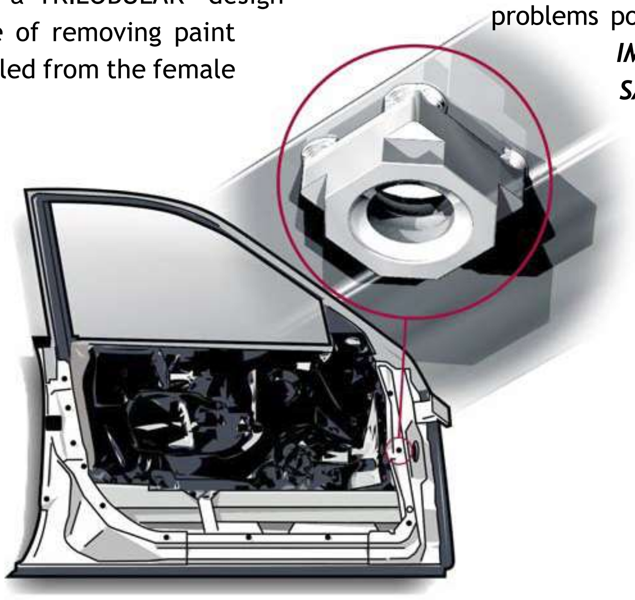
The cost of the components (square, welded nut and screw) was high but above all, the welding process increased the total assembly cost greatly.

Anyone having worked with the Car Industry know-how magic is the word "cost reduction", and our customer's engineers requested to know how this could be done.

CELO proposed modifying the stamping moulds for the metal sheet part, to make extruded holes and use a TAPTITE® CA self-tapping screw. The following advantages could be obtained:

- TAPTITE® CA was capable to eliminate the paint during insertion without any problems. The paint inside the hole did not block the screw.
- It saved the cost of the six nuts and the time needed to weld them.
- The TRILOBULAR® shape of the TAPTITE® CA thread ensured resistance to vibrational loosening.
- It eliminated the cross threading problems they had when using a metric screws.

Our proposal was extensively tested , and finally proved that the TAPTITE® CA screw not only solved the technical problems posed, but additionally offered ***IMPORTANT ASSEMBLY COST SAVINGS***.



12.- Examples of solutions for metal fixing problems

12.3 A study of small household appliance motors

We will show you a real example of a technical report that we carry out for our clients. We have obviously eliminated any reference to our client and slightly modified the data so as not to be related to anyone.

At present (September 2008) CELO has a library of more than 1000 cases that allows us to quickly find a solution for everyday problems.

Summary

The possibilities of assembling a metallic system belonging to a motor for a household appliance were determined (see figure 59).

The objective of the study was to determine which alternatives could we offer to:

- Solve the loosening problems caused by motor vibrations.
- Achieve a cost reduction for the assembly.

The client used a metric screw inserted into the metallic base with an extruded tapped hole. The operations prior to machining the hole were costly; in addition, the metric screw became loose due to the motor vibrations.

The following alternative was suggested:

- TAPTITE II® M5 X 30 mm self-tapping screw inserted into extruded untapped hole (ref. CELO TT85Z).

The advantages obtained were:

COST-SAVINGS:

The TAPTITE II® screw eliminated a working post from the assembly line as it was not necessary for someone to carry out the following operations: metal sheet extrusion and hole tapping. TAPTITE II® screw creates its own highly resistant female thread, without the need for extrusion.

MECHANICAL ADVANTAGES:

1. It eliminated the vibrational loosening problem: TAPTITE II® screw creates its own female thread in the metal (there is no clearance).

2. High assembly clamping: during insertion, TAPTITE II® screw increases effective thread length in the metal, which allows increasing the tightening torque to guarantee clamping.

3. It eliminated eventual cross threading problems: TAPTITE II® screw creates its own female thread, making it impossible for the screw thread to become cross-threaded in the nut.

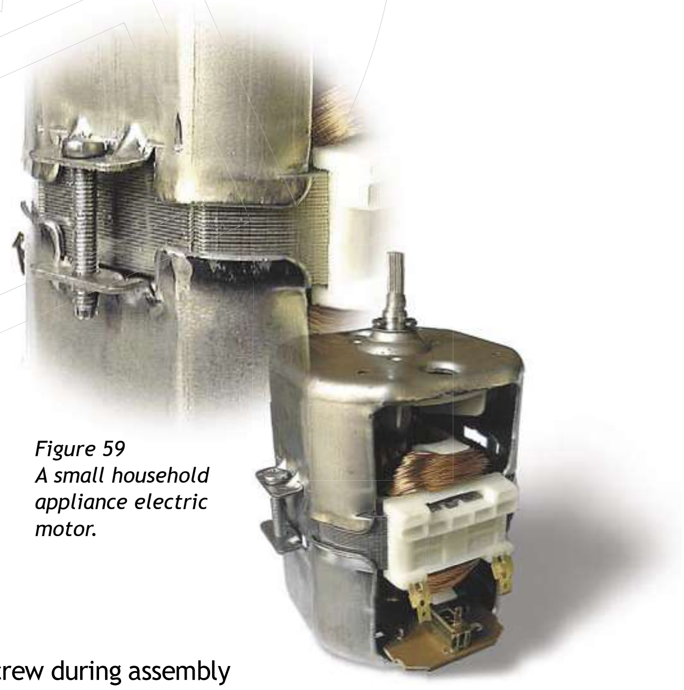


Figure 59
A small household appliance electric motor.

4. As shown in the insertion test carried out, the behaviour of the screw during assembly is excellent for its high safety margin: low drive torque and high system fail torque (thread stripping).

For the reasons given, CELO S.A. recommended using TAPTITE II® M5 x 30 mm threaded screw in the system.

Procedure

The materials used in the tests were the following:

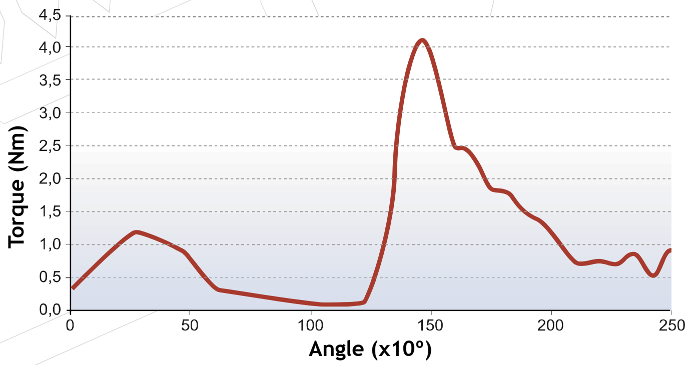
- Low revolution screwdriver (approx 400 rpm).
- Torque data was obtained using an Electronic Acquisition Data device (Schatz Accrat) measuring torque respect to rotation angle.
- Callipers.
- Steel metal sheet 1.5 mm thickness, to simulate assembly and to be able to carry out threading tests.

4.5 mm smooth drilled holes were made in the steel metal sheet where the TAPTITE II® screws were tested.

The insertion tests gave the following torque values:

Test	Drive torque (Nm)	Fail torque (Nm)	Safety ratio
1	1,07	4,14	3,87
2	1,00	3,84	3,84
3	1,39	3,89	2,80
4	1,29	4,18	3,24
5	1,32	4,82	3,24
Average	**1,21**	**4,07**	**3,40**

PERFORMANCE OF TAPTITE II® SCREW



12.- Examples of solutions for metal fixing problems

12.4 Refrigerator door

The substitution of a metric screw + toothed washer for a TAPTITE II® screw in a refrigerator door SAVED COSTS for the following reasons:

- Elimination of hole preparation operations: tapping, chips removal and lubricating.
- The cost of additional assembly elements: toothed washer.

IT INCREASED PRODUCTIVITY BY:

- Inserting the TAPTITE II® screw directly into the hole, without needing to position the washer.

Additionally, ASSEMBLY PROBLEMS WERE SOLVED:

- Loosening caused by door movement.
- Reprocessing parts caused by cross threading and thread stripping.

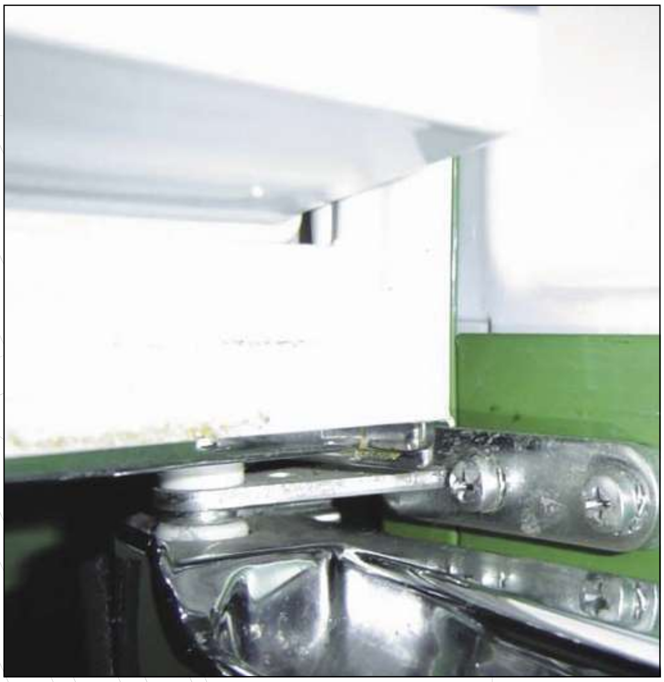


Figure 60
Refrigerator door hinge.

12.5 Aluminium valve body

The operation for tapping the female thread and chips cleaning for four holes in the die cast aluminium body of a high-pressure valve, caused the production manager to look for an alternative: in addition to the time invested in hole tapping, it caused an important bottleneck in the production process.

The cost saving using TAPTITE II® screws was estimated at 43,000€ regarding the reduction in time and the pre-assembly associated costs.