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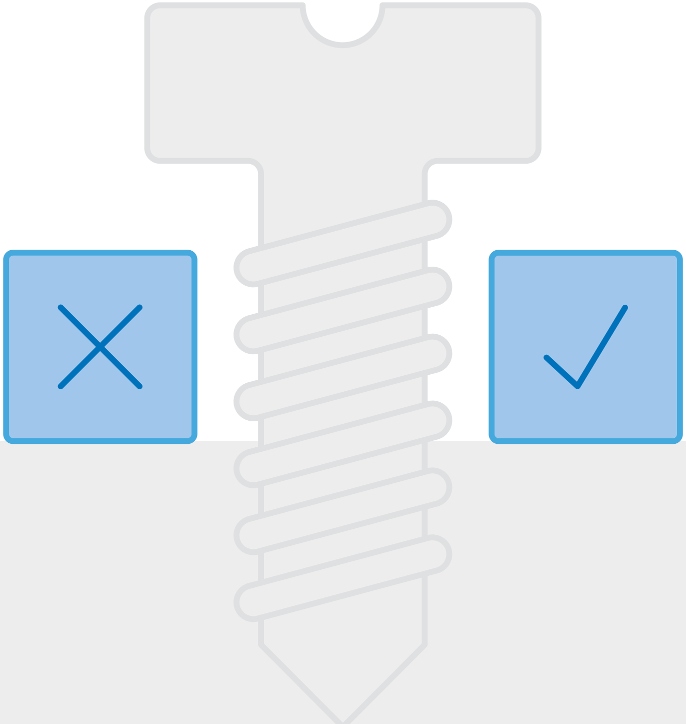

Making the right choice at the design stage

White Paper

Making the right choice at the design stage

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ASSEMBLY
TECHNOLOGY
EXPERT

MAKING THE RIGHT CHOICE AT DESIGN STAGE

Preface

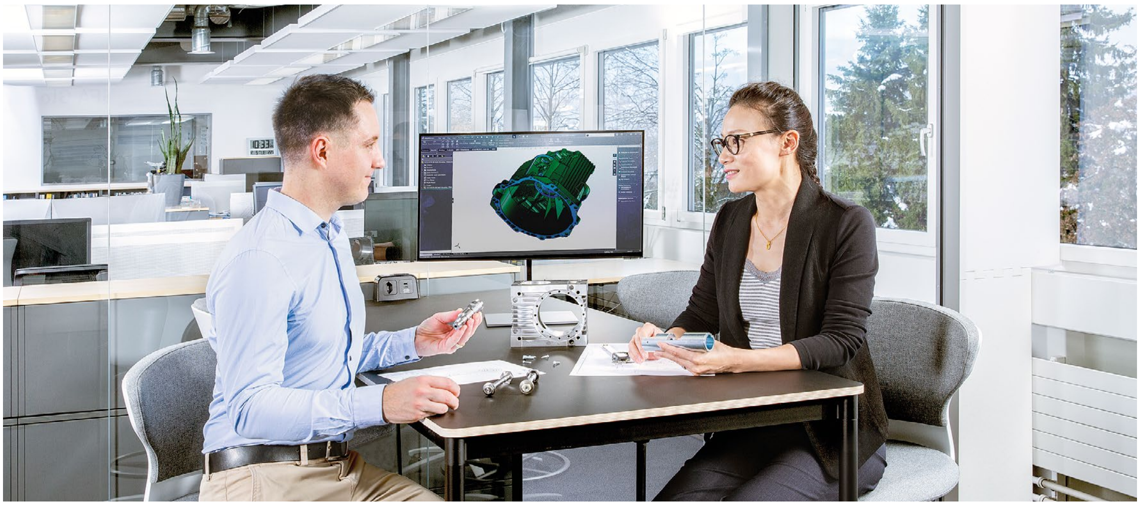
The following discussion on "Making the right choice at the design stage" is primarily tailored to industrial design engineers who have a mechanical engineering background and have been tasked with making hardware decisions. The purpose is to provide valuable insights and guidance that may benefit engineers, ranging from recent graduates to seasoned professionals, across diverse industries.

Please be aware that each topic, requirement and fastener characteristic discussed here could easily fill an entire chapter of discussion. This whitepaper provides a concise overview of the subject.

Design engineers working on fastener assembly often use past designs or similar products as references. However, if the product has undergone numerous changes and upgrades, the original assembly decision may no longer be suitable. It is wise to reassess the design requirements. Relying solely on decisions based on similar products may mean that important design factors that were not considered initially are overlooked.

The primary purpose of fasteners, as we know, is to simplify assembly and maintenance. Otherwise, alternative methods such as gluing, soldering or welding might be suitable.

In this whitepaper, we aim to strike a balance by addressing both product design practices and the decision-making process for fastener selection. The goal is to enhance productivity while minimizing associated risks.



MAKING THE RIGHT CHOICE AT DESIGN STAGE

The tasks

Selecting the appropriate fasteners is closely linked to a well-defined fastener strategy and can prove beneficial in numerous ways in the long term. Making intelligent decisions from the very outset not only ensures both the quality and the efficiency of your design, but also leads to savings in manufacturing and process costs.

Products nowadays can range from single-use items to products that require daily maintenance. A toy, for example, may be enjoyed for a short time, then discarded with minimal consideration. In contrast, an airplane, which is a mode of transport that thousands of passengers rely on to get from A to B, must be subjected to thorough inspections by ground crews and pilots prior to takeoff every single time.

It is a common tendency for people to often disregard fasteners once the core design features have been established. Consequently, this can lead to constraints with respect to available space, resulting in the need for non-standard fasteners, often referred to as "special parts" within the industry. Furthermore, an inadequate focus on fastener specifications can result in low benefits with high-cost alteration demands after a new product has been released for production.

Ensuring primary product functions

For executive product designers, the top priority is to ensure that the product fulfills its primary functions and – working in close collaboration with the Product Management team – to guarantee that it also meets market requirements. In cases where assembly requires fasteners, it is essential to consider the fundamental characteristics of these fasteners. The following information typically provides a solid starting point:

- Material type (e.g. steel, aluminum, composite, etc.)
- Material architecture (e.g. honeycomb, sandwich, etc.)
- Size

As a next step, it is essential to enhance the fastener information, considering the product's final use and taking into account the following criteria such as finish requirements or joint criticality, which leads to:

- Fastener strength
- Fastener type
- Material and corrosion management

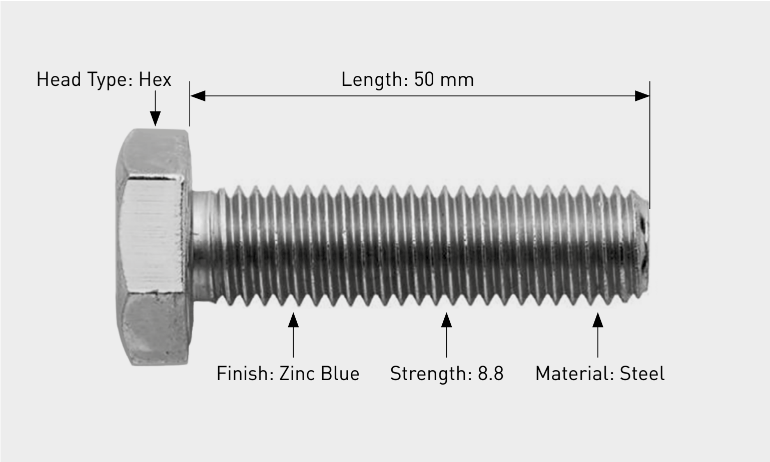


Fig. 1: Hex Cap Screw DIN 933 M10 x 50 mm Property Class 8.8 Zinc Blue

Figure 1 illustrates a sufficiently detailed fastener description that a supplier can understand and that Purchasing staff can use for sourcing purposes. The "fastener attributes" diagram offers a comprehensive overview of a hex cap screw. One common misconception when referencing industrial standards like DIN 933 is that it does provide a complete description of the fastener requirements. For instance, while DIN 933 certainly outlines the general appearance of the fastener, it does not specify its strength or finish.

Subsequent considerations

It may be necessary to take into account additional clarifications with respect to the following:

- Property classes/grades
- Finish
- Legislation such as the RoHS, REACH and WEEE Directives
- Mass production
- Ease of maintenance
- Safety and risks (e.g. loosening)
- Sustainability

Supporting tools – Bossard's CAD suite and T-section

Standard product information and drawings are readily available in catalogs. In addition, Bossard offers extensive technical details, and fasteners are clearly labeled with technical information. Bossard highlights relevant industrial standards, expectations and application information in the technical section (T-section).

The CAD suite is an online tool with comprehensive functionality. The visuals below show a BN 1392 hex socket head cap screw with an M8 x 30 mm, 12.9 black steel flange.

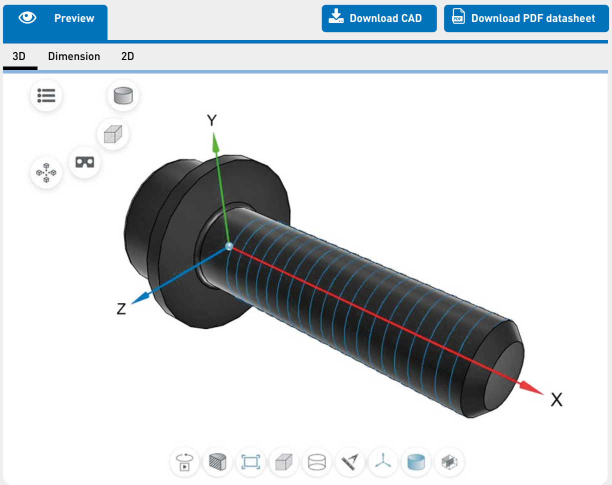


Fig. 2: Zoomable preview

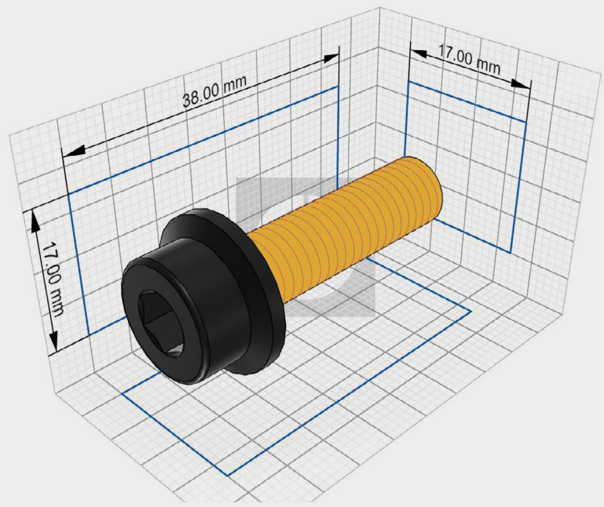


Fig. 3: Measurement functions

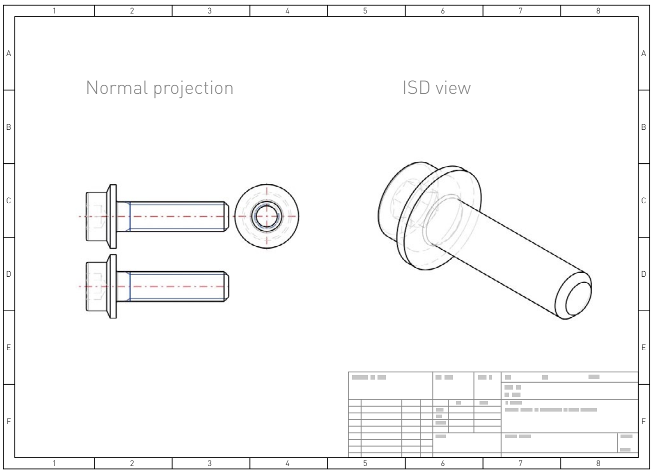


Fig. 4: 2D, e.g. three views with isometric drawing in frame (DIN)

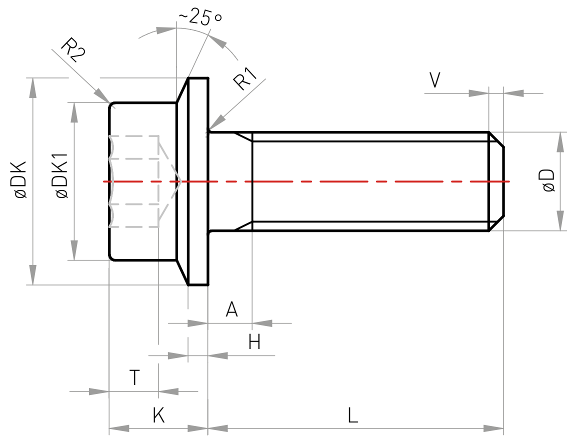
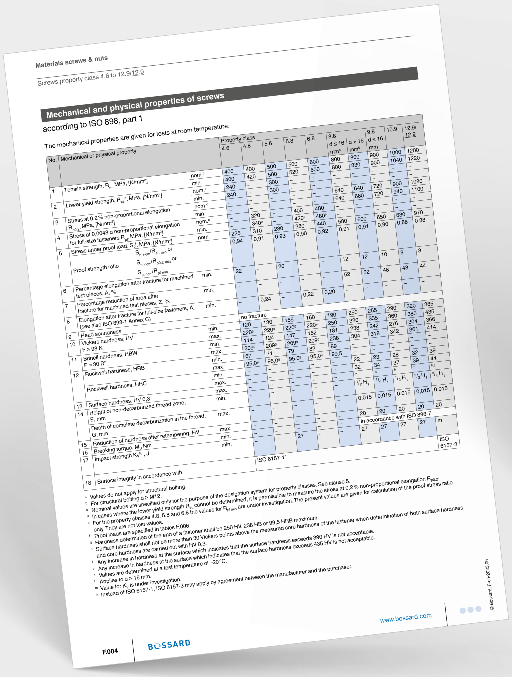


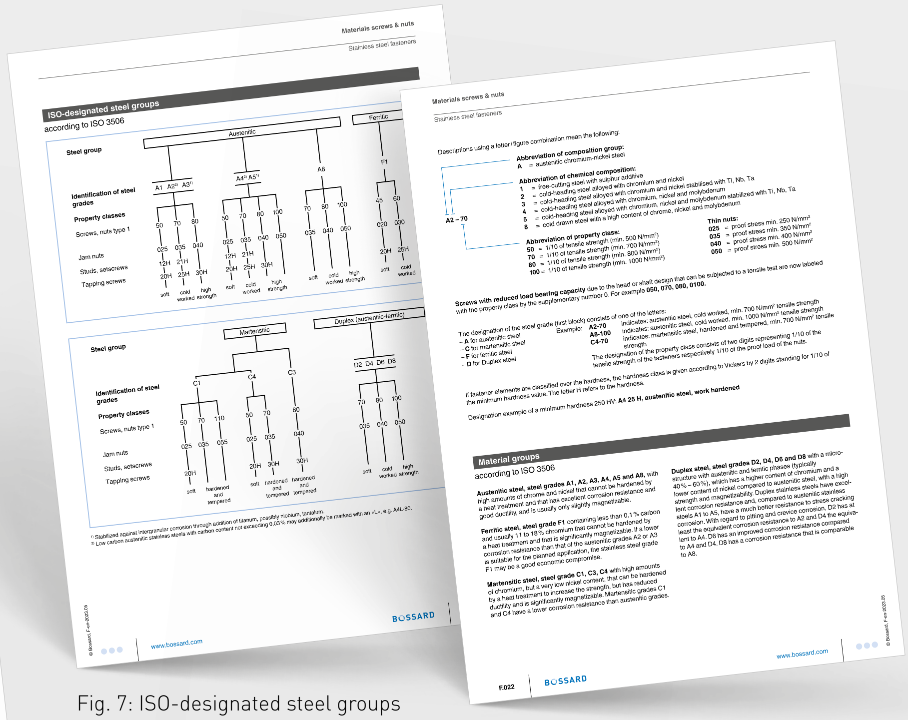
Fig. 5: Dimensioning (e.g. front view)

The technical section is available online and offers insights relating to fastening technology, electrical engineering, operating and control elements, and sealing and flow control technology.


Mechanical and physical properties of screws

according to ISO 898, part 1

Fig. 6: Mechanical and physical properties of screws


ISO-designated steel groups

according to ISO 3506

Material groups

according to ISO 3506

Fig. 7: ISO-designated steel groups and explanations, stainless steel fasteners

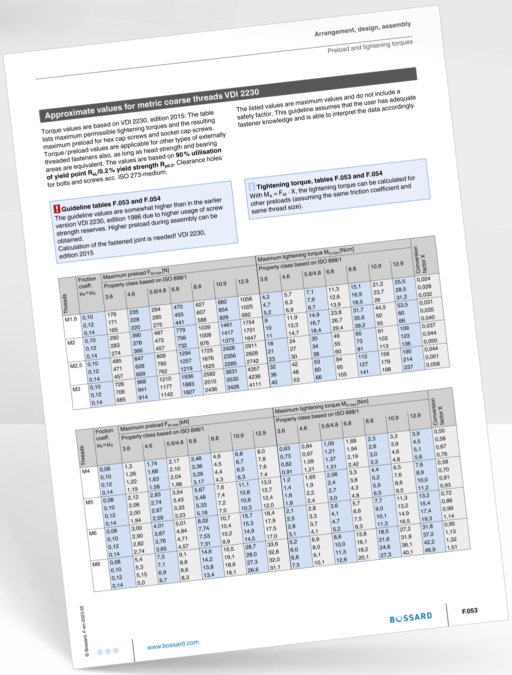

Approximate values for metric coarse threads VDI 2230

Fig. 8: Preload and tightening torque, as defined in VDI 2230

Check out our useful online calculators and technical section

Selecting fasteners is frequently an iterative decision-making process. Importantly, assembly decisions should be considered during the design phase, instead of postponing them to the final stage, when accommodating available space could become problematic. Having an understanding of the eventual manufacturing scenario helps with making informed decisions. This includes factors such as tool availability, capacity constraints and calibration processes.

Certain fasteners used in, for example, electrically powered products are designed to be versatile, accommodating both mass production and maintenance needs. A typical example of such a fastener is shown in Figure 6. It is evident that the fastener assembly recess is designed to facilitate efficient mass production assembly, while also being accessible for maintenance or servicing work when tools might not be readily available. In such instances, a basic small coin can be used as a simple and practical tool for the task.

Fundamental fastening rules

- Fasteners should consistently meet or exceed the quality and specifications of the assembled parts.
- Bolted joints must never be the weak link in the assembly and should maintain their structural integrity.
- Assembled fasteners should always be manageable and, as a result, be easily replaceable if needed.

Fasteners are primarily designed to securely join two parts together and, when necessary, to facilitate maintenance without any need for added complexities or additional responsibilities. It is best to avoid "loading" simple fasteners with additional tasks, such as handling high shear loads, serving as locators or functioning as liquid orifices. Various specialized solutions have been designed to meet these specific needs, and they should be considered as separate components or entities.

Fig. 9: Phillips pan head screw "Freedriv" form H with slot

Neglecting or overlooking fastener requirements, or failing to pay sufficient attention to them during the design stage, can lead to minimal advantages and costly change requests once a new product is in production or already on the market. This is demonstrated in the cost and benefit diagram. Prioritizing comprehensive design considerations, including fastening solutions, right from the very beginning may help to avoid unnecessary alterations and long-term expenses.

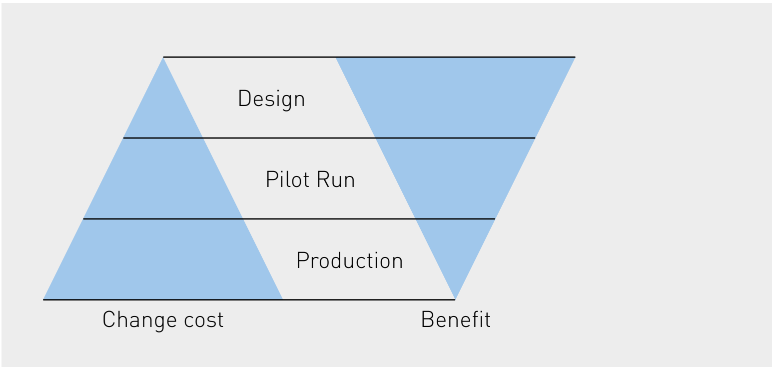


Fig. 10: Change costs increase and benefits decrease as the process progresses

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Availability

Fasteners have been used in industry as an engineering solution for decades. One important aspect in navigating the world of fastener selection is availability, which can significantly impact both cost efficiency and overall product quality.

In practice, it is generally advisable to look for industry standard fasteners first. There are numerous advantages to taking this approach, including well-documented characteristics, widespread availability, a variety of suppliers, efficient lead times and interchangeability, to name but a few examples. Of course, there are always cases where special parts are the better choice. However, practice and experience have shown that, by using industry standard parts, which are typically cold formed, as opposed to special items, which are often machined, waste can be reduced by up to 70 %. Notably, this figure does not even account for the environmental costs incurred.

Another often overlooked reason for industry standard fasteners pertains to engineering change notices. It is not uncommon to hear engineers downplaying the need for such notices when it comes to fasteners, dismissing them as a trivial and expensive procedure for a low-cost commodity. However, it is important to recognize that the processes and costs associated with an engineering change notice are independent of the overall product costs. This creates a dilemma, because engineers may underestimate the impact that change notices have on their projects, especially when it comes to seemingly insignificant components like fasteners.

Navigating the challenges of fastener procurement

Procuring fasteners from a dependable source can be challenging. Relying solely on cost as a practical measure is not always the best solution. While it might work for one-time acquisitions, it is essential to have a consistent and reliable source for repeat deliveries.

Design engineers should also be mindful of the fact that products used in prototyping may differ from those used in mass production. Lead times for obtaining these products may give rise to discrepancies and incur tooling costs.

A design engineer's primary responsibilities include crafting a product that is not only functionally excellent but also meets the market's demands. It is important to make a distinction between sound design, an effective solution and the quality of individual components. Even if the components are of a high quality and the solution is somewhat lacking, there remains a reasonable chance for success. However, when the solution is strong but the components exhibit inconsistent quality, the probability of success can diminish exponentially. A sound solution should never be jeopardized with substandard parts.

Another crucial consideration that design engineers must bear in mind is the awareness that a product or solution available at the design location may not necessarily be accessible at the mass production site. The procurement activity costs associated with making it available should be taken into account.

The "Machined or forged" diagram illustrates the cost difference between cold-forged fasteners and machined counterparts. Sometimes, what seems obvious may not be so if one's attention or focus is not in the right place. Design engineers would be well advised to prudently invest their time considering the use of cold-forged, mass-produced parts as opposed to special machined fasteners.

Machined parts	**Forged parts**
Small lot sizes	Min. lot sizes 100.000 to 300.000
Sharp edges	High production rate
Complex shapes	Nearly no waste
No cross recesses	Not sharp edges
20 – 70 % waste	Less complex shapes

Examining the costs reveals a picture that applies to almost all industries. The diagram in Figure 11 accurately represents a product's procurement costs. An ABC analysis conducted on the procurement side shows that 5 % of the costs are attributable to C-parts, while procurement activities account for up to 50 % of the costs. If the 5 % are converted into a total cost of ownership (TCO) calculation for the entire C-part process, it becomes clear that 15 % of the costs are attributable to the price of the fastener itself, while 85 % of the total costs include all of the other activities such as development, procurement, testing, warehousing, assembly and logistics.

Designers do not always see the aspects mentioned as primarily being their responsibility. Nevertheless, providing clear descriptions of fasteners and adhering to industry standards can significantly improve the process and save costs. This approach also makes fastener availability more manageable, increases efficiency and reduces dependencies.

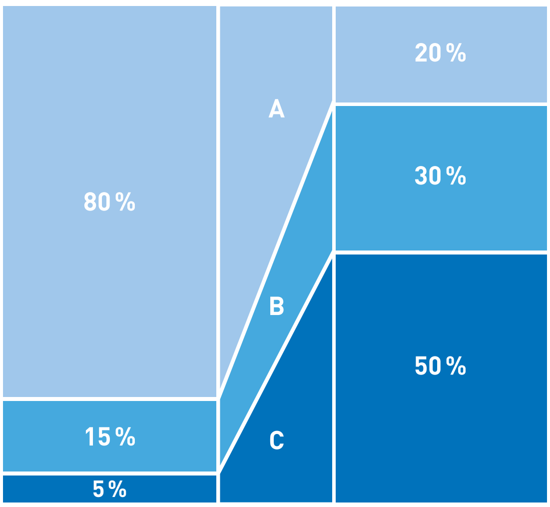

Fig. 11: A-parts: high value, low volume, low procurement activity costs; C-parts: low value, high volume, high procurement activity costs

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The decision

After selecting fasteners for the application, following fastening rules and cost and availability considerations, and before product release, the product typically undergoes extensive testing to validate the selection and make the final decision.

Reliable, independent and standard-compliant quality assurance forms the foundation of correct fastener selection and ensures continuously high product quality. Advancements in software and computing power have streamlined the testing process. However, test procedures are sometimes compromised due to the pressure to launch products quickly.

Fig. 12: Testing area

Selecting useful tests

Some fasteners require testing for determination of optimal assembly parameters. This is for example true for thread forming screws. Since the various materials, screw types, screw-in depths, hole geometries and other parameters do not provide universal information on torques, it is essential to conduct torque analyses to make reliable screw connections.

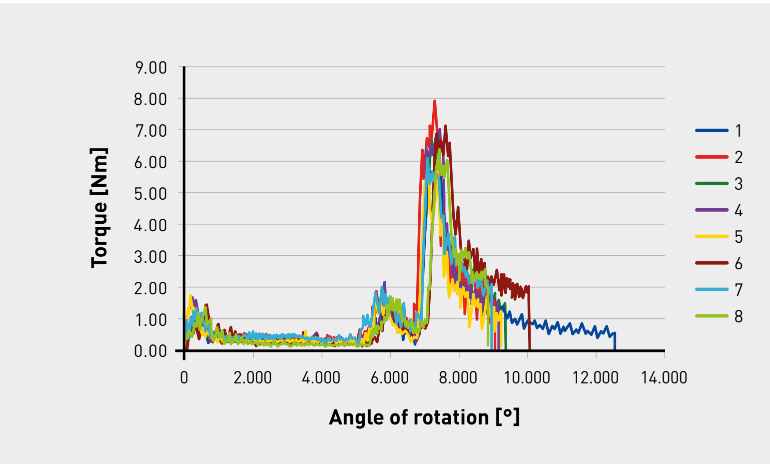

Fig. 13: Technically optimum torque/angle of rotation curves

Fig. 14: Torque analysis

One potential simulation test that can be performed at the product assembly stage is the Junker vibration test. It allows a comparison of different fasteners and their ability to maintain clamp load under extreme conditions in just 30 seconds. The test is carried out using a transverse dynamic load. The results provide the design engineer with information about joints' design safety and how effective their selected fasteners actually are.

For design engineers, determining a product's lifespan in relation to corrosion management is currently a significant challenge. This decision involves how long an assembly can function for without corroding and leading to malfunctions. While stainless steel is a straightforward solution, cost considerations in today's economic climate often challenge its use. Finding an ideal corrosion management solution for carbon steel is challenging, and the risk of hydrogen embrittlement defects in high-strength carbon steel with corrosion-resistant coatings must be managed carefully.

Additionally, addressing tolerance issues like bolt undersizing or nut oversizing to accommodate corrosion management solutions may compromise fastener strength. Striking a balance between all of these factors is crucial.

Customer feedback is a valuable source of information for identifying product weaknesses and driving improvements.

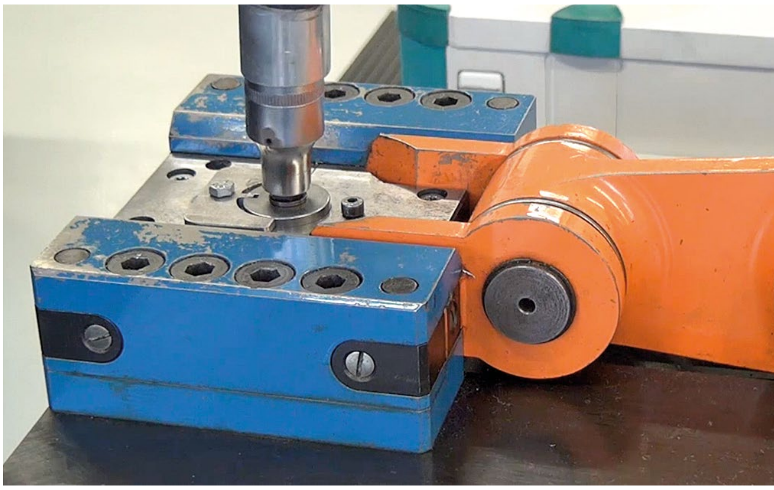

Fig. 15: Junker vibration test

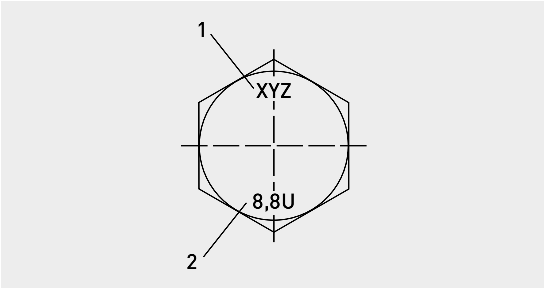

Fig. 16: Example of the marking used on hot dip-galvanized bolts and screws with threads undersized to tolerance class 6az before coating

1) Manufacturer's identification mark

2) Property class and additional marking

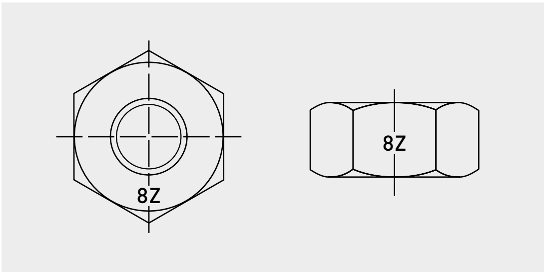

Fig. 17: Example of the marking used on hot dip-galvanized nuts tapped oversite to tolerance position 6AZ after coating

MAKING THE RIGHT CHOICE AT THE DESIGN STAGE

Summary

To ensure that the right choice is made, the fastener application and selection process should not be pushed to the bottom of the priority list during the design phase. It is crucial to carefully consider manufacturing and final assembly at an early stage to maximize the advantages before completing the design and progressing into mass production.

Selecting fasteners for an application decision may not be as straightforward as we might have initially thought. It is an iterative process. As we talk about C-parts, one could assume that the fastener price is the key metric. But focusing exclusively on the individual fastener price ignores the process costs associated with procurement, storage, assembly and so on. The profound impact that the fastener selection has on long-term product quality, assembly efficiency and cost-effectiveness should be taken into account. Following clear objectives and establishing fastening criteria and characteristics will help with defining clear guidelines for faster design decisions, and may eventually lead to a faster time to market.

Opting for a design that allows the use of industry standard fasteners facilitates availability, interchangeability and long-term cost optimization. Especially when specialized parts are required, it is advisable to choose a fastener supplier that can assist not only in the design of the fasteners or fastener connections, but also in prototyping and testing to ensure a consistent quality level.

Words of wisdom to bear in mind when choosing fasteners

1. There is no such thing as expensive or inexpensive fasteners or finishes
2. There are only cost-efficient designs, solutions and methods
3. The lowest-priced fastener may become the most expensive one!

About Bossard's engineering services

Bossard provides a range of engineering services and support for design engineers. We help our customers to make better fastening decisions when designing their products.

- Identify the ideal fastening technology.
- Define a fastening strategy for your application to speed up your design process.
- Select or design and verify specific fasteners and fastening joints to ensure quality and safety in your application.
- Reduce the variety of fasteners in your product to optimize the cost per unit.

If you need further assistance or have special finish requirements, please check out our contact page at **www.bossard.com** and talk to your nearest Bossard customer service representative.