Design your sheet metal parts to accommodate hardware

There are a variety of hardware options for different sheet metal fabricated parts. Choosing the best ones for your project should be considered during the design and take into consideration the type, the material, tolerance, and placement.

Common fastener hardware includes bolts and nuts, screws, and rivets – which all come in a variety of types, sizes, and materials.

Questions to help you identify the best fastener for your project

1. Is the joint permanent or will you be taking it apart for maintenance or repairs?

- If the part is going to be taken apart, opt for screws or bolts
- If the joint is permanent, choose rivets
- Hardware with self-locking threads will not be self-locking if they are reused

2. Will the joint be exposed to vibration?

- Joints that need to withstand vibration should use a conventional or blind rivet and avoid fasteners like tapping screws
- Threaded fasteners will loosen, especially with vibration
- Tapping screws can resist some vibration with material over 16-gauge 1.5 mm (0.0579 inches) in width

3. What strength requirements do you have for the fastener?

- You'll get the most tensile strength, shear strength, and twisting resistance from nuts and bolts
- Conventional rivets offer the next best option with respect to strength, followed by tapping screws and blind rivets
- Use blind rivets if you're working with thin material and the joint must not loosen

4. Is it possible to bring all components to an assembly machine?

- If the parts can't be moved to an assembly machine opt for blind rivets which allows the riveting tool to be brought to the part

5. Can you access the back of the joint?

- Blind rivets and tapping screws are the best option when the back of the joint is not accessible
- Conventional riveting machines can accommodate a distance of no more than 15 to 30 cm (6 to 12 inches) between the hole for the fastener and the edge of the joint
- Conventional rivets or nuts and bolts can work for joints with access to the back

6. How much backup space is available?

- Tapping screws must extend 9.5 to 15.9 mm (0.375 to 0.625 inches) beyond the back of the joint to fasten properly
- Less back space requires blind rivets

7. How hard is the part material?

- Hardware should be at least as hard as the material used to fabricate the part
- Self-clinching hardware should have at least a 20 point difference on the Rockwell B scale between the part and the hardware

8. How thin is the part material?

- Threaded screws will require material thicker than 3.2 mm (0.125 inches) for proper thread engagement
- Self-clinching inserts can be used to overcome limits for threat engagement
- Tapping screws work for materials in the range of 0.5 to 12.7 mm (0.02 to 0.50 inches)

9. What special fastener features are important for the joint that might limit your options?

- Consider finishes, materials, aesthetics, self-sealing etc

10. What is the best option with respect to cost?

- Don't compromise function for cost. Only factor in cost once you've identified which hardware will function properly for your joint
- Some hardware like nut and bolt joints requires more manual labor which impacts the cost while self clinching hardware has fewer parts and fewer assembly steps
- Short vs long run costs can vary

Rivets

Rivets are common, permanent fasteners which are used in both small and large applications. A rivet includes a head and a tail – which is beaten out or compressed once in place. Common types of rivets include:

SOLID RIVETS

- Generally seen as the strongest option among other types of rivets
- Heads can be flat, cone, button, or countersunk styles
- Can be clinched using staking, spin-roller forming, orbital forming, radial forming
- Variety of sizes and materials available including steel, brass, nickel-silver, bronze, copper, stainless steel, aluminum

TUBULAR RIVETS (SEMI-TUBULAR RIVETS)

- Like solid rivets but include a hole in the tail end which helps minimize the force needed and the deformation to the tail during installation
- Riveted surfaces can rotate, creating a permanent, hinged joint

BLIND RIVETS (POP RIVETS)

- Can be used when access to back of the joint is unavailable or limited
- Fast installation
- Requires a pre-drilled hole
- Specialized riveter required for installation
- Available as self-drilling, self-tapping, speed fastening

Screws

Screws are generally high strength fasteners which can be removed if repair or maintenance is necessary.

- Tapping screws create their own threads when driven in
- Can be thread-forming or thread-cutting
- Some can create their own hole, others require a pre-drilled hole
- Works for structural steel, brass, bronze, zinc, aluminum
- Lower cost than nuts and bolts or machine screws. Cost more than conventional or blind rivets
- Installed manually or with power tools
- Installation is time consuming
- Inconsistent sheet metal thickness can result in inconsistent torque with impacts hardware strength
- Available as pan head, hex head, round head, oval head, truss head, flat head, and self sealing

Bolts and nuts

Bolts require a nut or pre-tapped hole to form a joint. Washers are used to help spread the load over a larger area.

- Best option when high joint strength is required
- Pneumatic wrench is required for installation and removal
- Can be easier to remove than screws
- Requires access to the back of the joint
- More manual labor required for installation
- Common bolt types include: carriage, hex head, machine, shoulder, socket cap, socket set, and square head
- Common nut types include: cap, castle, coupling, flange serrated, hex, keps-k lock, thumb, structural, and wing

Compatibility and galvanic corrosion

Galvanic corrosion is always an important consideration when designing sheet metal parts with hardware. Issues arise when two dissimilar metals are in physical or electrical contact in an electrolyte solution. Under these circumstances, one of the metals can corrode more rapidly than expected. To avoid issues, whenever possible choose the same metal for fasteners as you have for the part. When that is not possible, choose metals close to each other on the galvanic table and take actions to eliminate the physical or electrical contact between the part and the hardware. This can be done with coating and non-conductive barriers. It's also possible to use a sacrificial anode to prevent galvanic corrosion. Please read Chapter 9 to get a better understanding of galvanic corrosion and how to prevent it.

Best practices to avoid galvanic corrosion for hardware includes:

- Use the same material for the hardware and the part if possible
- When using different materials choose ones as close as possible to each other on the galvanic table (see Chapter 9)
- When using different materials, choose a material for a fastener that will be slower to corrode than the part (see Chapter 9 for more details)
- Zinc coated fasteners should only be used with steel parts if the part is coated with aluminum, zinc, or galvalume
- Zinc and aluminum coated fasteners should not be used for parts made of copper or stainless steel

This table can be used to help with your selection of fastener and part materials

Base Metal	Fastener Metal					
	Zinc, galvanized steel	Aluminum and aluminum alloys	Steel and cast iron	Brasses, copper, bronzes, monel	Stainless steel type 410	Stainless steel type 302/304, 303, 305
Zinc, galvanized steel	A	B	B	C	C	C
Aluminum and aluminum alloys	A	A	B	C	Not rec-ommend-ed	B
Steel and cast iron	AD	A	A	C	C	B
Teme (lead tin) plated steel	ADE	AE	AE	C	C	B
Brasses, copper, bronzes, monel	ADE	AE	AE	A	A	B
Stainless steel type 430	ADE	AE	AE	A	A	A
Stainless steel type 302/304	ADE	AE	AE	AE	A	A

Key:

A: Corrosion of the base metal is not increased by the fastener
B: Corrosion of the base metal is marginally increased by the fastener
C: Corrosion of the base metal may be marginally increased by the fastener material
D: Plating on the fasteners is rapidly consumed, leaving the bare fastener metal
E: Corrosion of the fastener is increased by the base metal

Source: http://www.preservationscience.com/materials/metals/PGC.html

Tolerances and placement

In Chapter 3 we discuss the importance of understanding tolerances when designing sheet metal parts for fabrication. Tolerances help you understand minimum requirements for placement of hardware and fasteners. Always confirm tolerances and placement requirements with your custom fabricator so your design meets their requirements. The table below is provided as a guideline but can vary based on the material you're using, the fabricator's equipment and tools, and other factors. They may need to be adjusted for each project so your fabricator should be an important partner in your design stages.

Tolerances Guideline for Hardware in Sheet Metal Fabrication

	Tolerance Guidelines*
Hole to hardware	±0.254 mm (0.010")
Edge to hardware	±0.254 mm (0.010")
Hardware to hardware	±0.0381 mm (0.015")
Bend to hardware	±0.0381 mm (0.015")

*Please use these numbers as guidelines only and always check with your fabricator for their recommendations before completing your design.

The PennEngineering website provides additional details and specifications for common fasteners.

Common materials for fasteners

Stainless steel, steel, silicon bronze, brass, and aluminum are common materials used for manufacturing fasteners. Coatings using zinc, chrome, or hot dip galvanization are also used.

	Advantages	Disadvantages
Stainless steel fasteners	• Good corrosion resistance even if damaged or scratched	• Not as strong as hardened steel fasteners • Susceptible to seizing during installation
Steel fasteners	• Most common material used for fasteners • Can be used with or without surface coatings. Common coatings include galvanization, zinc or chrome plating • Galvanization improves corrosion resistance	• Uncoated steel will corrode • Different grades are available with different hardness and strengths so its important to know which one you should use
Silicon bronze fasteners	• Very good corrosion resistance • Primarily used in marine or saltwater environments • Stronger than brass • Sometimes used for aesthetic purposes	• High cost
Brass fasteners	• High corrosion resistance • Electrically conductive • Used mostly for its aesthetic properties	• Softer than other options
Aluminum fasteners	• Good corrosion resistance • Remains corrosion resistant even if damaged or scratched • Light • Aluminum alloys are common (manganese, silicon, iron, magnesium, zinc, copper)	• Softer than other options
Zinc plated fasteners	• Improved corrosion resistance • Appearance is shiny with a silvery or gold colour • Improved corrosion resistance • Finish is shiny and polished	• Steel coated with zinc will rust if the zinc plating is damaged
Chrome plated fasteners	• Improved corrosion resistance • Finish is shiny and polished	• Steel coated with chrome will rust if the plating is damaged • High cost
Hot dip galvanized fasteners	• Applies a thicker coating of zinc than zinc plating providing better corrosion resistance • Commonly used in outdoor and marine environments	• Hot dipped galvanized bolts are not compatible with any nuts other than hot dipped galvanized ones. • Hot dipped galvanized nuts are tapped differently because of the thickness of the coating.