Taking The Stress Out Of Clamping

How to choose the right clamp for your project, process or product

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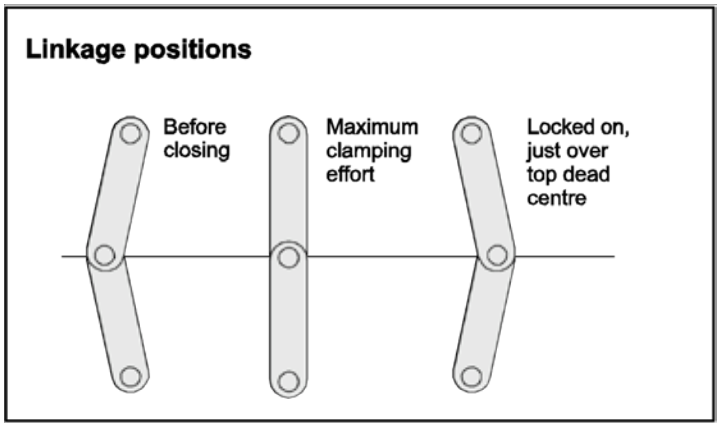
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Toggle clamps are over centre locking clamps, ideal for applications where the clamp is to be applied repeatedly. They are quick to use, much quicker than screw fasteners and they lock into position once applied. Due to the design of the linkage, toggle clamps are most suited to where there is little variation in the thickness of the part (however this may be accommodated by means, see later) and where the greatest force is required at the end of the clamp movement.

2**. Toggle Action**

The toggle action is the action of a toggle or over centre clamp. Toggle clamps consist of fixed length levers, which are connected by pivot pins. As the pivot pins come into line, large forces are generated and once in the over centre position the clamp is locked, unless the linkage is moved. Therefore, the advantage of toggle clamps is that they generate high clamping pressures, as they come into

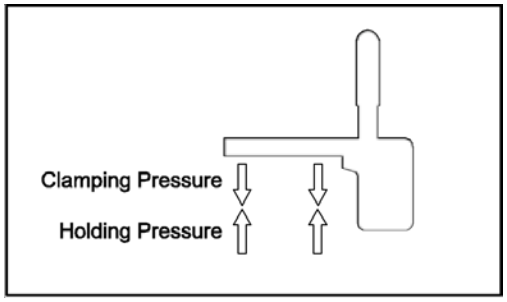


the locked position, and they remain locked until disengaged.

3**. Holding and Clamping Force**

There are two types of clamp forces to consider when determining which clamp to use: holding force and clamping force.

i) **The holding force** is the maximum that the clamp can withstand before deformation (the reactionary force).



ii) The clamping force is the force that the clamp will exert on the component or work piece. It is dependent on the effort applied to the clamp (e.g. the length of the clamp handle or the strength of the operator). So values of clamping force given in Sandfield's literature are only guides based on what an average person can apply.

4. **Using Toggle Clamps**

Toggle clamps were not designed to deform materials but simply to hold the component. The recommended practice is to position parts against a fixed stop, so that the clamp holds the component in position. Thus any forces generated during the process will be applied through the fixed stop.

Beneath the clamping point there should be sufficient support to prevent the component from moving and reduce deformation.

5**. Clamp Action**

There are four different clamp actions: vertical, pushing, pulling and squeezing.

Vertical action clamps: the clamp bar has a pivotal motion and clamps vertically down.

Within the vertical range there are three styles:

i) The most commonly used is also described as the 'vertical' clamp, where the clamp handle is at 90 degrees to the clamp bar.

ii) The horizontal clamp, where the clamp handle is at 180 degrees to the clamp bar. These are useful where space is restricted above the clamp as it is fitted with a low profile handle.

iii) The reverse clamp, where the clamp handle is at 250 degrees to the clamp bar. A reverse clamp is also ideal in areas of restricted work space since the clamp handle operates at the rear of the clamp.

Push action clamps are those in which the plunger operates in a straight line.

These may be used for location or as a brake as well as clamping or, if mounted vertically, as a press. Most of the clamps toggle in both the forward and rear positions.

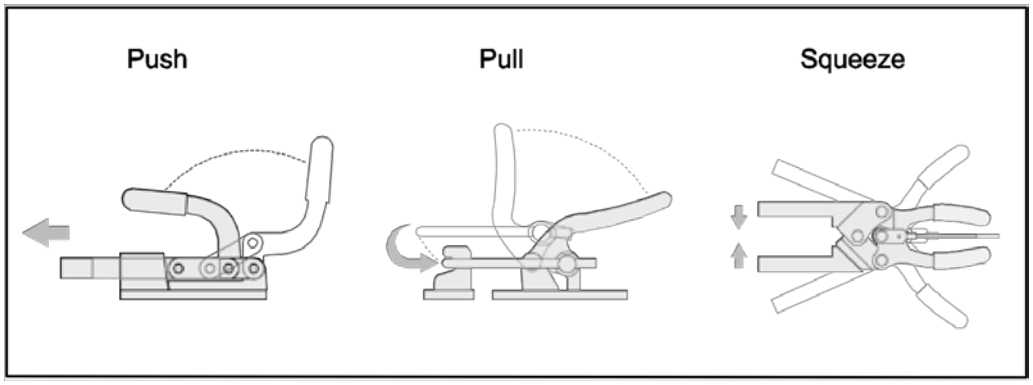
If you require the clamp to operate as an accurate locator, you must select a clamp that has been specifically designed for this application, or combine the clamp with a bushing arrangement. If you're operating through a bush, care must be taken that the clamp plunger and bush are in line, otherwise the clamp may stick.

Pull action clamps are also known as 'hook' or 'latch' clamps.

These are ideal where quick precise locating of two parts is required, such as clamping two halves of a mould, clamping down lids or latching doors. They operate in either the vertical or horizontal plane. The clamps are supplied with single hook or a double u bolt, which is threaded for adjustment. Different length hooks are available to suit particular applications.

Squeeze action clamps or plier clamps.

Plier clamps have a wide range of applications, including sheet metal working and welding fabrication.



6. **Repeatability**

For the majority of applications, the repeatability of a standard toggle clamp is adequate. However, in certain areas the repeatability of the position of the clamp foot is critical to the operation. If the clamp arm or plunger is carrying a tightly toleranced location pin, the positional repeatability must be considered.

Vertical clamps on most models have some lateral bar guidance from the cheeks of the side plates. If the precision of the bar is essential then the bar should be supported by a machined and hardened tenon block.

In some applications, only very light clamping pressures are required, hence hardened button stops may be fitted clamps so that the clamp bar stops on the button stop rather than the component.

For push clamps carrying location pins or acting as a precise location unit then you must select a clamp that has been specifically designed for location (i.e. fully bushed and tightly toleranced) or the location pin should pass through a separate bush.

7**. Setting of Clamping Pressure**

It is critical when setting the clamping pressure not to over set the clamp for the comfort of the operator and because excessive clamping force will shorten the life of the clamp. The clamping force may be adjusted by altering the spindle in the clamp bar or using shims to raise and lower the clamp body or under the clamp bar. The clamp should be set so that as the clamp is applied there is a 'light click' as the linkages move into the toggle position.

8. **Size of Clamp**

The size of the clamp is determined by:

i. The amount of clamping force or holding pressure required

ii. The amount of space available for the clamp (see point 10)

iii. The distance required from the clamp pivot to the clamping point

iv. The height under the bar.

If standard clamps do not suit your particular requirements, clamp handles, bars, hooks, or even the whole clamp can be modified to suit a particular application.

9**. Number of Clamps**

The number of clamps can be calculated by dividing the total force required by the holding force or clamping force of the selected clamp (whether you use the holding or clamping force is dependent on your application).

Please note that often holding force values given are close to the body and will reduce the longer the clamping arm. When determining the number of clamps always allow a factor of safety and round up the number of clamps required.

10. **Space**

Points to consider:

i. How much space is available around the clamp?

ii. What room have you got to mount your clamp?

iii. What reach do you require from the point of mounting to the clamping point?

iv. Do you have restrictions in the working area or access?

v. Are you able to perform the required operations with the clamp in position? For example, is there sufficient access for the welding or machining operation?

vi. Is there sufficient room to open your clamp or load and unload your component?

Assessing the space available for the clamp is critical when determining the type of clamp required.

11. **Ergonomic**s

Has consideration been given to the clamp operator who may have to apply the clamp repeatedly which could lead to fatigue and health-related issues?

Points to consider:

i. The position of clamp in relation to the operator. Is the clamp handle accessible? Is it in a position that allows it to be used repeatedly?

ii. The clamping force required.

How much effort does the operator require to apply the clamp? Has the clamping pressure been set correctly? There have been a number of studies carried out that provide working guidelines to the amount of effort needed to apply the clamp. These take into consideration things like the height of the clamp in relation to the operator and the effort required to apply the clamp. For example, 5.3 kg above shoulder height and 7.7 kg at shoulder height (see “Woodson et Al Human Factors Design Handbook” or “Auburn Engineers Ergonomics Design Guidelines”.)

i. Is there a risk that fingers or hands will be trapped where the clamp is positioned? Is the operator at risk of trapping or pinching hands or fingers whilst operating the clamp?

ii. If a clamp is to be applied repeatedly then the comfort of the operator needs to be considered.

You can avoid the risk of injury by using a more appropriate sized clamp; extending or repositioning the clamp handle; or modifying or designing a specific clamp for the application.

12. **Pneumatic or Manual Clamps**

Do you require manual or pneumatic clamps? This will depend on various factors such as:

i. The number of clamps you must apply

ii. The frequency of the clamping cycles you require,

iii. The critical nature of the clamp to your operation

iv. The accessibility of your clamp

v. Your budget.

Choose a manual clamp:

i. If the clamp will operate infrequently

ii. If the clamp needs to be accessible

Choose a pneumatic or automated clamp

i. If the clamp is to operate at a high frequency,

ii. If the clamp is critical to the operation or the quality of your product,

iii. If the clamp will be mounted, remote or inaccessible to the operator

The following table will help you to decide whether you require manual or pneumatic clamps…

Criteria	Manual Clamps	Criteria	Pneumatic Clamps
Few clamps to apply	√	Many clamps to apply	√
Infrequent clamping cycles	√	Frequent clamping cycles	√
Limited life of fixture	√	Long life of fixture	√
Accessible Clamp Positions	√	Inaccessible Clamp Positions	√
Non Critical Application of clamp	√	Critical Application of clamp	√
Budget Constraints	√	No Budget Constraints	√

Most pneumatic clamps can have the facility to be manually applied and then opened under power.

This is particularly useful if you need to accurately position the parts as the clamp closes (for example, when clamping small brackets).

Be aware of the Health and Safety implications of pneumatically operated clamps.

Heavy duty clamps generally have cast or forged handles, hardened and ground headed pins and bushes and the pins tend to be replaceable.

Light and medium duty clamps are generally constructed from pressed components, and are not always fully bushed and they do not tend to have replaceable pins.

When deciding whether a heavy duty clamp is required, consider the following:

i. The clamping force required

ii. The frequency of operation

iii. Life of the tooling

iv. The environment the clamp will operate in (and the likelihood that the clamp will be damaged)

v. The cost of the down time should a clamp fail compared with the additional cost of using a heavy duty clamp.

14**. Mounting Options**

There are generally three options to mount a toggle clamp:

i) **Base-mounted** - the clamp side plates are flanged and the clamp mounts flat to the surface.

ii) **Template-mounted** - the clamp fits over a blade. This may be an advantage if you require the mounting blade and the clamping point to be in line.

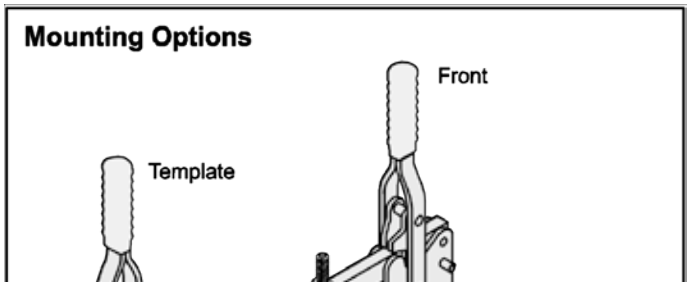
iii) **Front-mounted** - the mounting face is at 90 degrees to the clamp bar. This may be achieved either with a clamp with front-mounting side plates or, if different heights are required, with a template mounted clamp and a separate front mounting plate, which allows heights to be varied.

15**. Clamp Bars**

There are four different types of clamp bar available for vertical clamps. They are:

i. ‘U Bar’ - these allow the spindles to be adjusted in the clamp bar.

ii. ‘S Bar’ - the clamping position is fixed at a pre-determined length. This type of bar is most suitable when it is critical that the clamping point remains fixed or



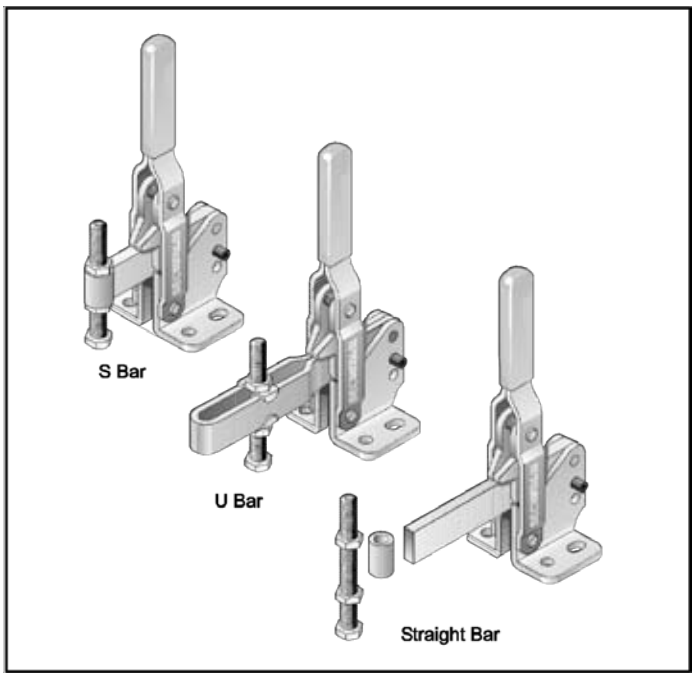
if a high clamping force is required in which case the spindle may move in a "U' bar clamp.

iii. Solid bar - a solid bar clamp is provided with a loose bolt retainer, so you may cut the clamp bar to the required length and weld the bolt retainer.

iv. On some heavy duty models of clamps, the clamp bars are available with a series of tightly toleranced dowel and clearance holes which are drilled relative to the clamp mounting holes. This allows for fitting shims and Mylar blocks.

Alternatively, if you require a bespoke clamp arm or attachment, then the heavy duty 'CH' range are designed to allow custom made arms to be readily attached.

Any bar configuration maybe provided directly on request.



16**. Clamping Feet**

The type of surface you are clamping onto will determine the type of clamp foot you require. If it is critical not too mark the surface then you should use a protective covering on the clamp foot. For example, a neoprene-tipped spindle or a neoprene cap that fits the bolt head. Generally, the neoprene-tipped spindle provides a more secure, longer lasting solution. Neoprene-tipped spindles are generally flat-bottomed but if you are clamping on an angle then you may wish to consider neoprene spindles with a semi-circular cross-section to reduce the possibility of indentation.

If the clamping surface is not flat then you may need a swivel or self-levelling foot. These also have neoprene caps to protect the clamped surface.

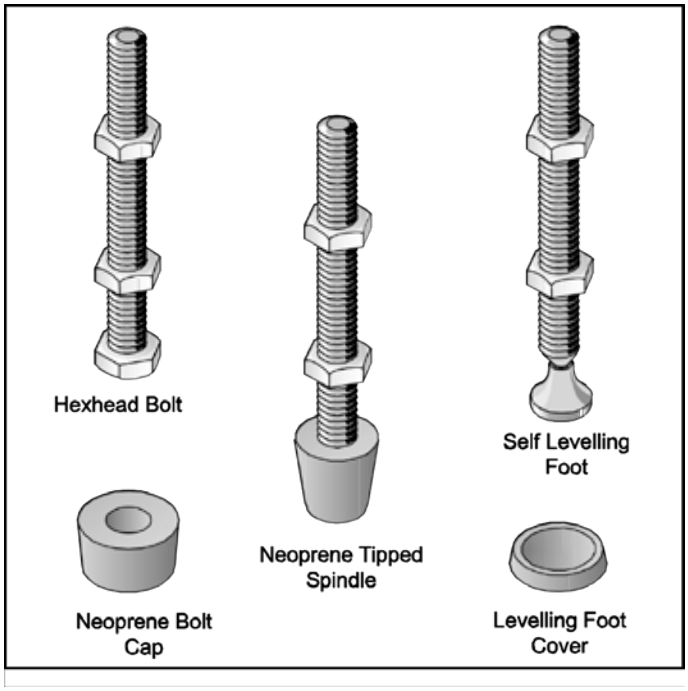
If you are clamping a complex surface and it is critical that the clamp follows the profile then you may require ‘form blocks’ or ‘mylars’ to match you component surface.

17**. Component Thickness**

What is the thickness of your component, does it vary and by how much? Is a standard toggle clamp suitable for your application? A toggle clamp clamps to the same position each time. If your component varies in thickness then this variation could be accommodated by using springs or spring washers under the clamp bar. The strength of the spring required can be calculated from the clamping force required.

Alternatively, if the variation is large, then you could consider using a cam clamp. Cam clamps are not over centre clamps locking clamps; the clamp bar forms a cam and they can take up several millimetres in thickness.

[move this illustration to point 16]



18**. Environment, Materials and Coatings**

When determining which clamp is suitable for your application, you must consider the environment the clamp will operate in. Predominantly, toggle clamps are zinc-plated mild steel and the heavier duty clamps tend to be chemi-blacked.

If there is potential for the clamps to rust or seize, stainless steel clamps may be more suitable. Take into consideration special industry requirements such as in the food or pharmaceutical industry where grade 316 stainless steel may be specified. In highly abrasive situations aluminium may not be permitted.

If the clamps are going to be subjected to temperature extremes then special cylinders or lubricants may be necessary, or it may be advisable to consider the impact of dissimilar materials.

If the clamps are being used in a curing process consider if there any restrictions with regards to fumes given off from the clamps which may interfere with manufacturing process.

If you require clamps to operate in particular environments then we may be able to simply provide the solution.

19**. Secondary Locks**

Is it critical to the application that the clamp remains in position either from a functional or a Health and Safety perspective? Toggle clamps are over centre clamps that lock. However, in certain applications, particularly with vibration, the clamp may come undone. If this is critical then a clamp with a secondary lock should be considered. This may be either a simple pin or a secondary locking trigger.

20**. Clamp Detection**

Is it critical to your process or product quality that the clamp has been applied and remains in position? In these applications it is possible to use a manual clamp with a built-in proximity switch which will detect when the clamp is closed.

Sometimes a standard clamp just won't fit and rather than make-do, we offer you the opportunity to have a clamp custom-designed for your specific purpose.

Our team will inspect your drawings and discuss your engineering problem and design a clamp that completely meets your needs. We can also build and test the clamp, if required.

Alternatively if you employ a clamp which sits in a mission-critical part of your process or where the cost of failure is high, we invite you to contact our specialist consultancy team. Our team will seek to understand the engineering problem and your unique requirement. Using this information we will help you specify or design the solution most appropriate to your stated outcomes.