Ten Factors for Specifying Hinges

Incorporating hinges early into designs helps keep costs down and options open.

More and more, designers consider fasteners, latches and similar hardware early in design, but leave hinges until the last minute. Although many engineers face shortened design cycles, considering hinges late in a design cycle may severely limit some options. This can compromise the design, forcing nonstandard parts into products while increasing costs and reducing performance. Designing hinges into an application can be easy, especially when keeping the following considerations in mind.

How Much Load Will The Hinges Bear?

Strength requirements play a major role in any design. In specifying hinges, crucial considerations include not only the weight of the door, but all possible external sources of load. Think about dynamic loading - will equipment be mounted on the door? More importantly, will people hang on the open door?

Manufacturing and installation variations normally result in unequal load distribution among the hinges. Keep in mind that as the ratio of the door width to height increases, the stresses becomes more severe. Determining strength requirements means considering the total applied load from all sources.

For maximum strength, place the hinges as far apart as possible on the longest edge of the door. Depending upon the design, use a closer hinge spacing to stiffen the door or to ensure sealing against a gasket.

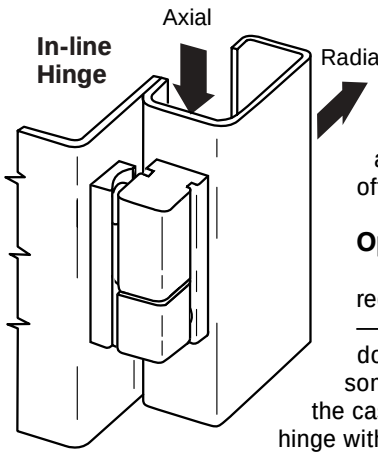
Consider The Overall Design

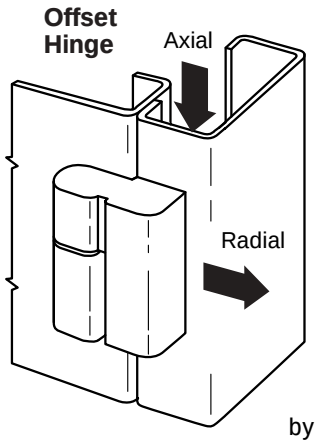
Consider how much flexibility there is in the design of the door and frame. Requirements such as gasket sealing and aesthetic constraints can help determine the best hinge options for an application. Often door and frame designs can be modified to suit a readily available hinge, keeping overall costs down.

Concealed Versus Externally Mounted Hinges

Concealed or internal hinges mount on the interior part of the door and frame. They provide a clean outer panel and improve security by eliminating attack points for vandals. If using a concealed hinge, consider the amount of internal protrusion.

For example, with electronic enclosures, inside space is limited because of numerous internally mounted components. Also, concealed hinges may re-strict access and cause other issues, namely installing and hiding the mounting hardware. These hinges work with specific door and frame configurations, so product and mounting options should be designed with them in mind.





Exposed or external hinges are mounted on the exterior of the door and frame. They solve the problem of limited interior space, offer greater strength than concealed hinges, and can allow for a greater door-opening angle. They are also easier to fit to an application any time in the design process, and are more universal — one hinge design can often be used for a variety of applications.

Because exposed hinges are visible on the outside of the product, aesthetics may be a factor. Take care to ensure the design of the external hinge blends well with the application. Also, evaluate the risk of users hitting or snagging the hinge if it protrudes too far off the door.

Door And Frame Configuration

Both concealed and external hinges can require specific door and frame configurations, requiring different ways of mounting. When selecting an externally mounted hinge, determine whether your door and frame configuration calls for an in-line hinge or an offset hinge.

Opening Angle

Many applications today require hands-free access — the ability to keep the door open without someone holding it. If this is the case, think about using a hinge with a built-in detent feature to hold the door open at a preset angle, or an adjustable-friction feature that lets the user tighten or free-up the door swing. Both of these hinge styles eliminate secondary mechanical supports like gas struts or door stays.

Detent and friction hinges are two products in one — the hinge and the door stay. They also reduce the number of parts purchased and stocked, cut down on installation time by installing one product, and lower overall cost.

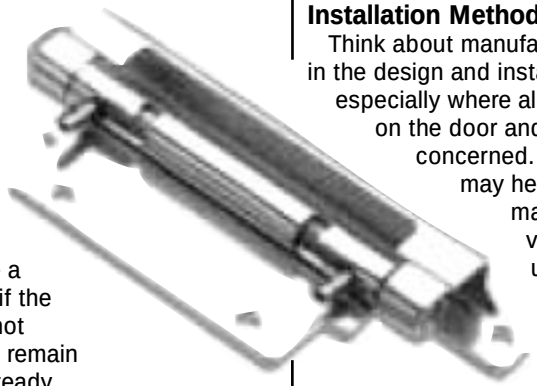
Most detent hinges come with preset opening angles such as 80°, 120°, and 170°. Many also provide a negative detent angle (such as –5°), which lets the hinge go slightly past center when closed, holds the door securely against the frame, and reduces vibration. some cases, this eliminates a latch. Detent hinges are recommended for small, lightweight applications.

Removability/ Access To The Interior

If a user or service technician requires full access to the interior of the cabinet or enclosure, removable hinges may be the answer. Removable hinges are also valuable if the product ships unassembled or if the door and frame are manufactured in different locations. Lift-off hinges or hinges with retractable pins are easy to remove.

Lift-off hinges let the door be removed in a single motion without using tools. Simply lift it off the hinge pins mounted to the frame. The door is replaced by lowering it back over the hinge pins. Both hands remain free to maneuver the door.

Hinges with retractable pins allow removal of the door without lifting the door. To remove, retract the hinge pins and pull the door straight off. To replace the door, align the two halves of the hinge and extend the hinge pins, locking the door back into place.

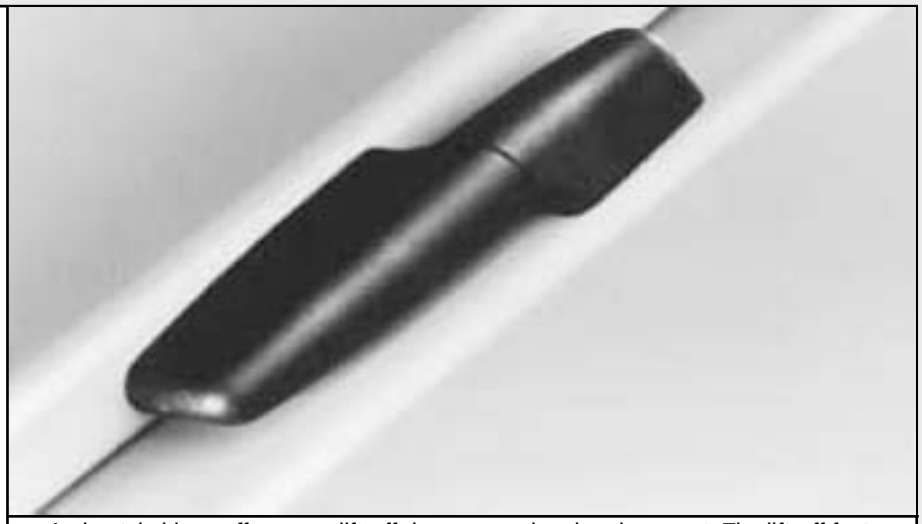


Hinges with pins that remain permanently attached to the leaf won't let the pins drop out or get lost. Retractable hinge pins are a better choice if the hinge axis is not guaranteed to remain vertical and steady.

Industry Specifications

Choosing a hinge can depend on where the final product will ultimately be used. When designing the product and selecting hinges, consider any regulations or specifications required. For example, hinges used on outdoor enclosures housing electronic equipment may be required to meet NEMA and IP standards. In the food-equipment industry, NSF certification imposes stringent guidlines on materials and design.

Hinges can be certified to meet a specification as is, or the specification may require evaluation of the complete system. Choose a hinge capable of meeting all product standards. Understanding industry requirements ensures selecting the best hinge for an application, saving time and money in the certification process to bring the product to market.



A pin-style hinge offers easy lift-off door removal and replacement. The lift-off feature provides unrestricted access inside an enclosure, cabinet, or storage space.

Installation Method

Think about manufacturing tolerances in the design and installation process, especially where aligning the hinges on the door and frame are concerned. Slotted holes may help compensate for manufacturing variations. Also, understand where in the manufacturing process the hinge is installed. Determine if the leaves will be assembled to the door and frame at the same time or in different locations and assembled later. Mounting methods include screws, studs, rivets, welds, and adhesives. Also, determine clearance for any tools needed for installation, as well as the hardware itself.

Materials

In evaluating materials, consider potential environmental conditions and the end use of an application. Temperature range, chemical exposure, UV radiation, and moisture conditions influence hinge material selection. Hinges come in a variety of materials such as steel, stainless steel, die-cast zinc, and engineering plastics. Steel and stainless steel hinges withstand wide temperature variations. Engineering plastics and stainless steel offer corrosion resistance. Plastics reduce noise and vibration.

Factors such as strength, corrosion and UV resistance, weight, and aesthetics influence hinge selection.

Aesthetics

To optimize overall quality and cost effectiveness, balance performance needs with aesthetic judgment. Large, external hinges give an impression of great strength. Concealed hinges remove appearance concerns. To enhance an application's design, most plastic and powder-coated hinges are easily customized to meet color specifications.

Some hinges include snap-on covers that conceal mounting hardware, giving them a more polished appearance. Mounting hardware can also be concealed by installing the hinge from the back side of the door or frame.

How Strong A Hinge Is Needed?
Consider These Factors:

1. How much does the door weigh?
   To determine the weight of a door, multiply the volume by the density of the door material. For a simple rectangular door, this equates to length X width X height X density. Better still, if a sample of the door is available, put it on a scale.

2. Where is the center of gravity of the door?
   For a uniform thickness door, the center of gravity (Cg) will lie in the exact center of the door. Unfortunately, most doors aren't uniform. If a sample of the door is available, here's a hands-on method to determine the Cg, regardless of the door shape:

   a. Hang the door from one corner so it can pivot freely.

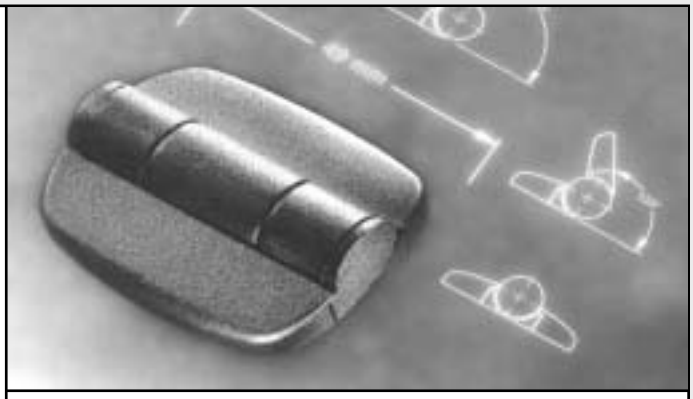
   b. Attach a plumb line to the pivot so the line hangs freely. (A chalk line is ideal for this).

   c. Mark the line on the door.

   d. Repeat steps a through c twice more, hanging the door from a different corner each time.
   e. All three lines should cross at the same point, which is the Cg of the door.

3. What other loads will be applied?
   Consider the weight of components that might be fastened to the door. Will electronics or cooling equipment be mounted on the door? Are there hooks or handles to hang something on? Also, keep in mind the unintended uses of the door: Will people use the door to support their weight as they stand up? Might someone sit or climb on the door? Is load applied by wind or a moving object? Are forces generated by compressing a gasket or from pressure within the enclosure?

4. Whenever possible, test the hinge in the application.
   Theoretically, the vertical load on a door will be distributed evenly among the hinges. In practice, however, variations in mounting and build tolerances often mean that one hinge takes the brunt of the load. Testing the final product is always recommended.



Considerations At A Glance:

10 Questions To Ask
When Designing A Hinge

1. How much load must the hinge withstand?
   Determine the size and weight of the door, along with attachments.

2. How do hinges fit in the overall design?
   Designing the hinge in early may allow use of an available hinge.

3. How much space can you afford inside or outside the enclosure?
   Think about concealed versus externally mounted hinges.

4. How do you plan to mount or access the door?
   Door and frame configurations play a critical role here.

5. How far must the door open?
   Detent and friction hinges allow the door to remain open without secondary mechanical supports for hands-free access.

6. Is removing the door a requirement?
   Lift-off hinges offer fast door removal for quick and complete access to the interior of the cabinet.

7. What specifications (environmental, sanitation, etc.) must the hinge and enclosure meet?
   Many hinges are already certified to meet various industry standard specifications.

8. How will the hinge be installed?
   Consider the manufacturing and installation process carefully.

9. Do you need to meet specific material requirements?
   Think about environmental conditions the end product may face.

10. How large a role do aesthetics play in the design?
    Balance performance needs with aesthetic judgment.

Calculating The Amount Of Force Each Hinge Bears

The following examples show a basic calculation for determining the amount of force acting on each hinge. These calculations assume uniform distribution of load among all the hinges. In practice, however, manufacturing variations and build tolerances often mean that one hinge will bear most of the load. Apply adequate safety factors and test the hinge in the final application.

1. For a door with a vertical axis, using two hinges:

A. Calculate the axial load (R_{axial}): add the forces generated by the door and components attached to it (F_{door}) to the external force applied to the door (F_{ext}) and divide by 2:

$$R_{axial} = (F_{door} + F_{ext}) / 2$$

B. Calculate the radial load (R_{radial}): multiply the forces generated by the door and attachments (F_{door}) by the distance from the hinge to the center of gravity of the door (d_1).

Then multiply the external force applied to the door (F_{ext}) by the distance from the hinge to an external load on the door (d_2). Add these two values and divide by the distance between the hinges (d_{hinge}):

$$R_{radial} = [(F_{door} \cdot d_1) + (F_{ext} \cdot d_2)] / d_{hinge}$$

2. For a door with a horizontal axis, using two hinges:

A. The axial load (R_{axial}) = 0
B. Calculate the radial load (R_{radial}) of each hinge:
1. Multiply the forces generated by the door and attachments (F_{door}) by the difference between the distance between the hinges (d_{hinge}) and the distance from the hinge to the center of gravity of the door (d_1). Then divide by the distance between the hinges (d_{hinge}):

$$R_{radial\ 1} = F_{door} \cdot (d_{hinge} - d_1) / (d_{hinge})$$

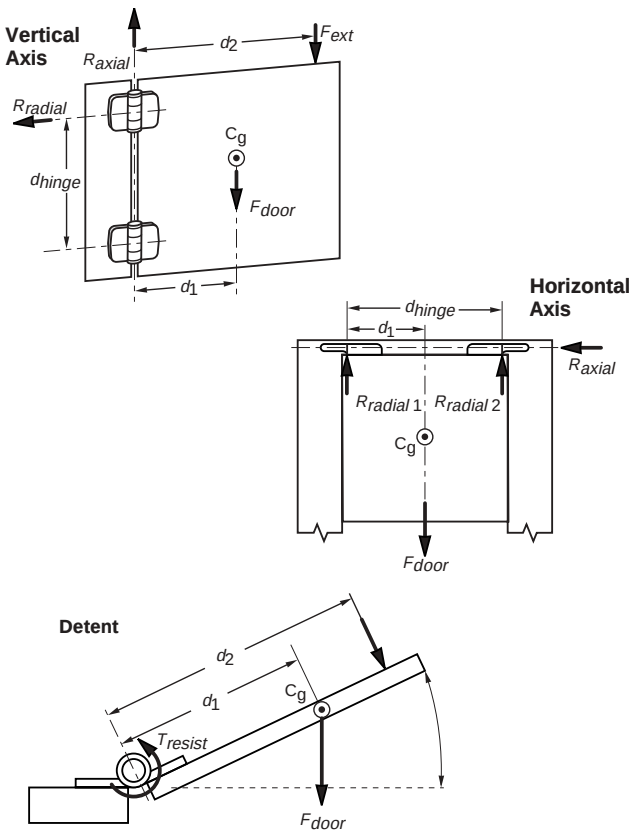
2. Multiply the forces generated by the door and attachments (F_{door}) by the distance from the hinge to the center of gravity of the door (d_1) and divide by the distance between the hinges (d_{hinge}):

$$R_{radial\ 2} = F_{door} \cdot d_1 / (d_{hinge})$$

3. How to calculate the torque required for detent or friction hinges on a door with horizontal axis:

A. To find the torque (T_{door}) generated by all the forces acting on the door and attachments: multiply the distance from the hinge to the center of gravity of the door (d_1) by cos(θ) and by the forces generated by the door and attachments (F_{door}):

Hinge Operation Illustration



$$T_{door} = d_1 \cdot \cos(\theta) \cdot F_{door}$$

This is the minimum torque required to hold the door in position with no external load.

B. Calculate the total torque required to overcome all hinges on the door (T_{resist}): multiply the number of hinges per door (n) by the torque required to overcome the detent or frictional force of the hinge (T_{hinge}).

$$T_{resist} = n \cdot T_{hinge}$$

Choose the number and type of hinges such that the total torque required to overcome all hinges on the door (T_{resist}) is greater than the torque generated by the door forces (T_{door}).

C. To calculate the external force applied to the door, subtract the torque generated by (F_{door}) from the total torque required to overcome all hinges on the door (T_{resist}). Then divide by the distance from the hinge to an external load on the door (d_2):

$$F_{ext} = (T_{resist} - T_{door}) / d_2$$

F_{ext} represents the external force required to overcome the hinge torque and move the door from the position θ.