



# *Positioning with Constant Torque Friction Hinges*

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Constant torque friction hinges can provide a cost and space efficient solution for positioning vertically or horizontally mounted panels. Reell manufactures a wide variety of standard friction hinges, but more importantly, we can develop a custom hinge specific to your application.

***Is a Constant Torque Friction Hinge the Best Solution for Your Application?***

The following are a few examples of applications of constant torque friction hinges:

**Horizontal mounting:**

Automotive hoods, automotive trunks, automotive lift-gates, grill lids, freezer lids, toilet seats, copier lids, boat hatches, and washer and dryer lids

**Vertical mounting:**

Flat panel screens, entrance doors, automotive doors, cabinets, enclosures, refrigerator doors and displays

Constant torque hinges can be used successfully to position a panel in any of the above applications. Constant-torque friction hinges are used in some of the above applications and not at all in some others. Other solutions are also used, including simple pivots, simple springs, spring/cam counterbalances, gas springs, over-center springs, a combination of constant friction torque and a one-way bearing – the list seems endless.



***Why so many different solutions for what seems to be the same problem – the positioning of a panel?***

Final application requirements often need a more complex solution than “I want to position this panel and have it stay put”. Sometimes these needs are realized only after trying several different solutions. Once the underlying need is fully defined, the application requirements usually favor one solution over another. Look closely at the hinged panels in your present vehicle: the hood, trunk, lift-gate, door, visor, or glove box. Each uses a different solution based on their unique requirements.

Let’s compare application requirements and constant friction torque capabilities to see how well a constant torque friction hinge would meet your needs. The following factors are used in the evaluation:

**1. Positioning requirements**

- a. Infinite vs. discrete positioning, multiple vs. open/close positioning
- b. Force characteristics
- c. Positioning accuracy

- 2. **Ergonomic effects** – the effects of the hinge application on the end user
- 3. **System effects** – the effects of the hinge on the system in which it functions
- 4. **Failure modes/environmental effects**
  - a. Unanticipated use (or abuse!) of the hinge by the end user
  - b. Environmental effects of temperature, vibration, wind, humidity, etc.
- 5. **Space requirements** for the hinge application
- 6. **Specifying torque requirements**

**1. Positioning requirements**

**A. Does your application require that the panel be positioned at any point within a certain range of movement?**

If so, a constant torque hinge can offer an advantage over other solutions. When correctly specified, the hinge allows the user to move the panel to any position within a certain range of movement (infinite positioning). The panel remains in place until the user repositions it.

Other applications may require a discrete number of stopping positions such as automotive doors. These applications generally use spring or detent type hinges with 2 or 3 stopping positions.

Other potential applications may specify an open/close position. For this function, a simple pivot, sometimes combined with some form of latching device, is often a cost-effective solution.

**B. What force characteristic is acceptable or required for positioning a panel?**

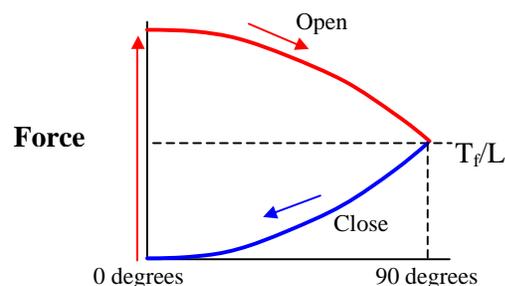
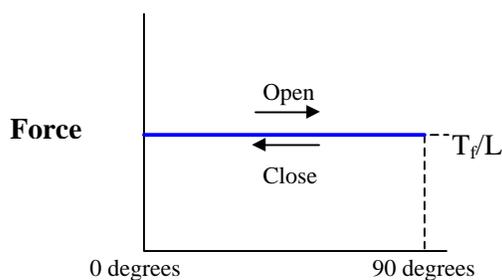
Application of a constant torque hinge will result in a predictable force or “feel” to the user, if the panel is mounted vertically as opposed to horizontally. If mounted vertically, the force required to move the panel will be constant.

If the panel is mounted horizontally, the user will experience a varying force from the combined effects of gravity and the changing position of the panel. Lifting the panel from the horizontal position requires twice the force of moving it at the 90-degree position. In contrast, moving the panel to a horizontal position requires little force, because the frictional torque is specified as approximately equal to the gravitational load at that point. To position horizontally mounted panels weighing less than 5 lbs, this force characteristic makes a constant torque hinge a good choice.

**Vertical Mounting**



**Horizontal Mounting**



Some applications require a different force characteristic than that offered by constant frictional torque. In such cases, an additional solution or a different solution altogether is required. The following three examples illustrate these requirements:

- i. Automotive door positioning requires that the holding force at position be 3 times to 5 times the force required to move the door between positions. A spring/detent type mechanism meets this criterion. In a constant torque hinge, the holding force and the force required to continue movement are almost the same, making it unsuitable for this requirement.
- ii. A lightweight, horizontally mounted panel that requires a lower lifting force from the horizontal position than afforded by constant friction torque alone may be realized by adding a spring/assist that will lower the beginning force requirement.
- iii. One laptop computer manufacturer desired that the display “self-close” when approaching closure, much like some kitchen cabinets. This seemingly small modification to the force characteristic required a variable (not constant) frictional torque element, plus a spring/cam/over-center mechanism. The resulting design was clever, large, and expensive. (Self-closing kitchen cabinet hinges, by the way, also employ spring/cam devices, but not constant or variable friction torque.)

When considering hinge solutions it’s essential to consider the force characteristic desired. If you can use the force characteristic of a known solution, you will decrease design time and cost. Designing a mechanism to achieve a unique force characteristic will increase design time and cost. Few requirements will affect the choice, the price, the size, and the effectiveness of your hinge solution as much as force characteristic will.

### **C. Does your application require precise positioning?**

Reell constant torque hinges are manufactured with virtually zero “free-play” and “spring-back”, meaning they stay where they are positioned. However, when mounted in systems such as in panels and supporting structures, the system itself will probably “spring-back” to some extent, resulting in less than precise positioning. The reason is that the system is almost always more compliant than the hinge, and will deflect under the load of hinge movement. When the load is removed after the panel is positioned, the system relaxes or “springs” back. The actual amount of “springback” or positioning error depends upon the torque of the hinge and the compliance (a.k.a. spring constant) of the system.<sup>1</sup>

If this system springback characteristic is undesirable or unacceptable, a detent-type hinge may provide a better solution. Some detent mechanisms – like those in automotive doors – actually generate a force that “pulls” the panel into the detent position, avoiding the spring-back problem.<sup>2</sup>

1. Customers sometimes ask us to reduce system springback by redesigning our hinge to provide “increased stiffness”. We must politely but firmly decline such requests for obvious reasons of physics.

2. This avoids the springback problem but may create a different problem. For example, when a car door has almost, but not quite, reached a detent position but then encounters some obstacle. We particularly notice this when the detent mechanism is on the door of the car adjacent to ours. And the obstacle it encounters is the door of our own car.

## **2. Ergonomic Effects –how the hinge affects the end user**

As mentioned earlier, constant torque hinges can be made to position any size load. However, constant torque is normally used on comparatively small panels because it requires a proportionate amount of force to position the load. In the case of horizontal mounting, the user must exert a force of more than two times that of the load to be positioned. In the case of a laptop computer, users find this requirement acceptable. If constant friction torque alone were applied to position an automotive hood, it might find use as a human strength-training device, but as little else.

In any event, ergonomics must be carefully considered in any hinge application. Our own experience testing end user force requirements concludes the following:

Force Required by User	Acceptability
0-5 lbs	Acceptable
5 – 10 lbs	Marginal
>10 lbs	Unacceptable

By this reasoning, we recommend that horizontally mounted panels in excess of 5 lbs weight be positioned with a combination of constant torque plus some kind of spring assist or a one-way bearing to offer more acceptable ergonomics. Reell will be glad to work with you to customize a solution to your needs. The following two examples, however, illustrate why the above force guidelines are just that: guidelines-and why a simple force metric may not suffice to determine what is acceptable to a customer.

- a. Reell was asked by an appliance manufacturer to develop a hinge for a top-loading washing machine. Two unique requirements made the normal, simple pivot unacceptable for this lid.
  - i. The washer lid had to be self-supporting at any opening between 20 and 60 degrees because the space above the washer did not allow 90 degree opening.
  - ii. The washer lid must close “gently” from any angle of 20 degrees or less.

Reell successfully met these requirements by customizing a hinge with constant torque from 20 to 60 degrees, and with declining torque from 20 to 0 degrees. The force at opening was higher than a simple pivot lid, but was still acceptable to marginal by the above criteria.

The opening force, however, was higher than end users expected, which concerned our customer. The customer finally chose a – an over center spring design, which allowed for a lighter-than-normal opening force, positioning only at 60 degrees, and was a very cost-effective solution. Note that the deciding requirement (opening force) was one not originally specified, and that the final solution met only part of one of the two requirements originally specified. This experience reinforces the need to understand and review requirements, particularly those of an ergonomic nature.

- b. In recent years there’s been a change in how automotive hoods are held open. Some years ago when I traded the family station wagon for a new minivan, I noticed that a prop rod had replaced the spring counterbalance of my old vehicle. The “new” technology required considerably more force to open the hood, required a two-handed operation to position and lock the prop rod, and put the operator at risk of injury if a gust of wind were to suddenly disengage the prop rod. Why did a manufacturer provide a solution with such ergonomic issues?

Certainly lower cost was one reason. Infrequency of use may have been another. With the advent of 100,000-mile tune-ups and rapid oil changes, owners open the hoods of their cars less frequently. (Notice that manufacturers are not putting prop rods on trunks or lift-gates. On the contrary, power assist devices are now available in addition to the traditional mechanical and gas springs normally used.)

As this example shows, ergonomics is a complex issue for hinge applications, and is influenced by frequency of use and different requirements for consumers versus service professionals.

### 3. System Effects (Or, how will the hinge affect whatever you attach it to?)

Just as the hinge will affect its human operator, so will it affect the system in which it is mounted. One advantage of Reell’s constant torque hinges is their ability to develop and sustain very large torques in very small package sizes. The very large stresses required to develop this torque mean that all components must be designed with the structural strength and ability to withstand the wear caused by this loading.

However, because the hinge mounting points are usually located near the pivot center, the developed torque also transmits very large reaction forces to these mounting points. Both structures mounting the hinge must be designed to withstand these forces, which can be hundreds of times greater than that experienced by the end user. In the case of a constant-torque friction hinge replacing a simple pivot, some reinforcement of the mounting areas is almost always necessary, not simply to minimize deflection, but to avoid catastrophic structural failure.

So the prop rod in my minivan not only eliminated two spring counterbalances – it also reduced the structural reinforcement necessary, reducing weight and cost. This made the manufacturer happier than it made me.

#### 4. Environmental Effects (the effects of surroundings – including the end user – on your application)

Two kinds of environmental effects must be considered: human, and everything else.

- a. The “everything else” includes unusual environmental conditions such as temperature extremes, high humidity, salt spray, acid baths, vacuum, etc. Reell hinges are normally specified for use in temperatures from 0 – 60 deg C. Application temperatures outside this range, and/or any other unusual environmental conditions should be communicated to us early in the process to determine if either a standard design or design changes could meet these requirements.
- b. The “human element” can be the most unpredictable of all, and the hardest to account for in determining actual load requirements. Several examples will illustrate:
  - i. A corporate purchaser of laptop computers qualified potential products by throwing each computer against a conference room wall. If it still functioned, it passed the first test. After all, these laptops had been advertised as “ruggedized”
  - ii. Reell once redesigned a laptop hinge late in the development phase, so it would pass a drop test by our customer. Although this drop test had been performed by our customer on earlier programs, it had never been communicated to Reell. A stiffer mounting configuration in the new design transmitted higher loads to the hinge under impact. A simple design change allowed the hinge to pass the test. Had the requirement for a drop test been identified years earlier, considerable design time could have been saved.
  - i. Remember the prop rod for the hood of my minivan? A few years ago, a well-meaning elderly neighbor helped my wife check the oil level after she had raised the hood.<sup>1</sup> This check completed, he proceeded to close the hood in the manner in which he was accustomed. Placing both hands on the open hood, he pressed down firmly. The prop rod folded over 180 degrees with just enough resistance to feel like the counterbalanced hood of every Chevrolet Caprice he had ever owned for the past 35 years. The hood latched with a satisfyingly familiar sound, and apparently the gentleman was near-sighted enough to overlook the bulge in the hood from the bent prop rod.<sup>2</sup>

These illustrations all serve to emphasize that the nature of the customer’s decision process or an end user’s application is often made clearer by experience than by science.

1. This story does not reflect on my wife’s automotive competence. She understood there were at least two dipsticks under the hood and was looking for the right one

2. No, we never told our neighbor what he had done – he was only trying to help. (I straightened the prop rod, left the bulge in the hood, and held my breath every time I opened the hood thereafter.) We have since replaced the vehicle with another minivan equipped with all the latest automotive technology including a similar –and annoying – prop rod.

#### 5. Space Requirements (How much space do you need? How much do you have?)

Reell’s clip technology has the advantage of producing reliable friction torque in a minimum of space. However, enough space must be provided to ensure both reliability of this function as well as its structural integrity. As mentioned before, internal stresses can be very high, as can loads transmitted to mounting structures. Space needed, particularly for custom designs, must always allow sufficient safety to account for variability of end use. The following starting points may be used as guidelines for a new design:

5mm Clip Products	Max Torque	Minimum Mailbox (bracket) Width
	5 Kg cm	5.2 mm
	7 Kg cm	5.8 mm
7mm Clip Products	Max Torque	Minimum Mailbox (bracket) Width
	5 Kg cm	7.2 mm
	7 Kg cm	7.6 mm
	10 Kg cm	8.0 mm



For higher torques than these, or for more complete information on space requirements, please contact our design engineers. We strongly recommend consulting with Reell's design engineers before finalizing your space requirements to help ensure that all design factors have been considered.

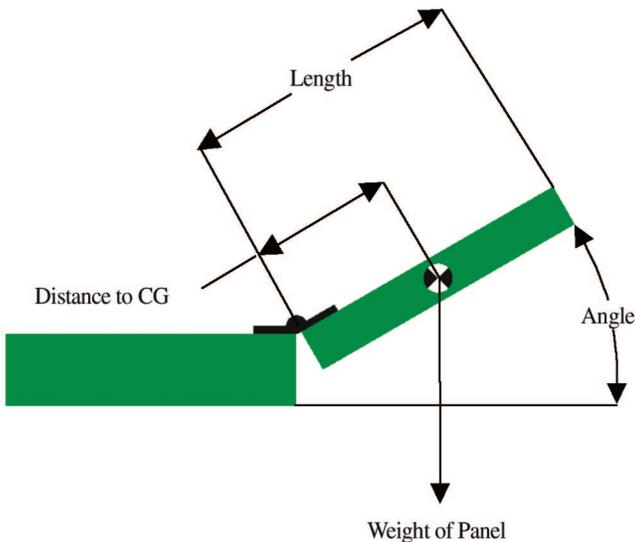
## 6. Specifying torque with Reell's technology

Reell's engineers look forward to working with you to develop your torque specification. The following factors and relationships may be used as a starting point for determining your torque requirements:

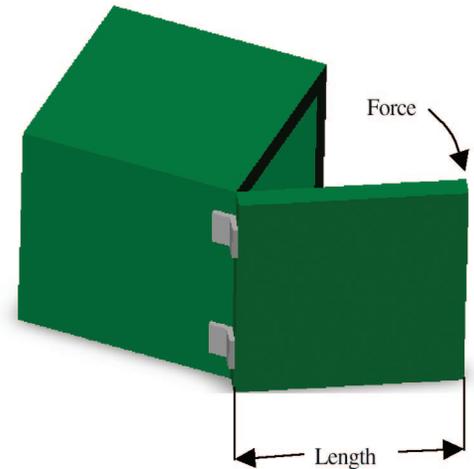
### Vertical Mounting:

The force needed to position a vertically mounted panel with constant torque friction hinges depends on the total hinge torque, and the distance (Length) from the hinge pivot to the point of force applications.

This positioning force should be equal to or greater than other loads that the panel must withstand without moving, including unintentionally applied (human) loads, and wind loads.



$$\text{Torque Min} = \text{Weight} \times \text{Distance to CG} \times \text{Cos}(\text{Angle})$$



$$\text{Torque} = \text{Force} \times \text{Length}$$

### Horizontal Mounting:

The constant friction torque needed to position a horizontally mounted panel should be at least equal to or greater than the opposing torque imposed by gravity (panel weight).

Additionally, other externally applied loads that the hinge must withstand must be considered additive to the constant friction torque, i.e.:

- User applied loads (touch-screen)
- Vibration (use on a moving vehicle)