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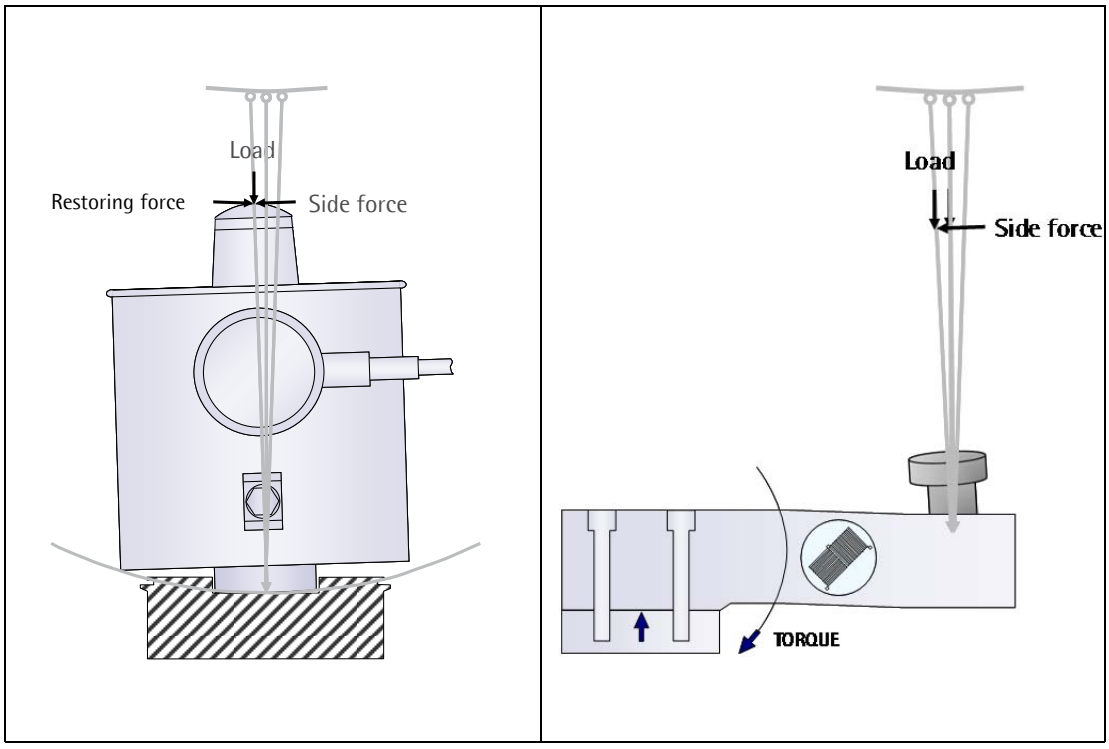
Load cells for a Portable Structure

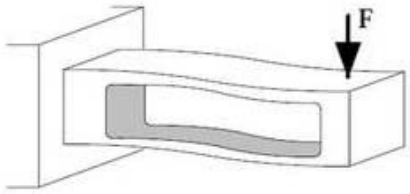


providing measurable solutions

We know that a weighing system must be rigid to get good results. We should also know that a three point system is inherently more stable than a four point system as three points define a plane. We know that we can convert a four wheel portable vessel to a three point system by using a double frame design “sandwich concept.

Now, let’s review the basics common to most types of load cells.

During a measurement, weight acts on the load cell's body and causes elastic deformation. The body has some spring constant. This strain (positive or negative) is converted into an electrical signal by a strain gauge installed on load cell.



Let’s take a look at a few types:

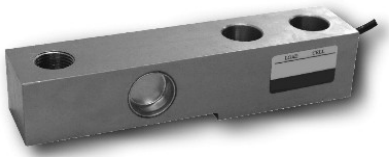
<u>Beam Type:</u>

Beam type load cells Include Single Point, Bending Beam, Shear beam and Square Beam. Each manufacturer may use a different name or slightly different location for the strain gage, but here are some common examples.

Bending Beam examples- Strain gage mounted horizontally.



Shear Beam examples- Strain gage mounted vertically.

The beam type load cells are typically bolted to a support at one end by 2 mounting screws and the other end is attached to the live load. If you were to remove the cover, you would most likely see a machined out area. The strain gage is generally mounted on one of the surfaces that has been machined down. Strain gages will have different characteristics depending on their position on the cell. These types of cells often give a high output with relatively low force applied and are very useful in platform scales. The cells are designed to give an accurate reading in the principle axis. When side forces or torsional forces are present the strain gage will give an unwanted output which may add or subtract from the actual weight.

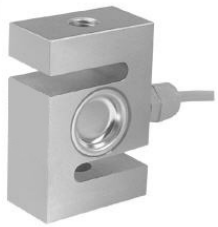
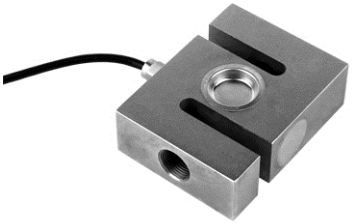
Canister Type:



This type of load cell is ideal in high capacity applications and non-scale applications where unwanted forced, vibration, or temperature fluctuations are likely to occur. The key element in these types of cells is that they are not hard mounted. They generally have a mounting kit that holds the load cell in place but allows for thermal expansion and protects the load cell from unwanted forces. There are several types available depending on the manufacturer- the style to the left is a compact model for applications with lighter capacities and when a low profile is desired.

"S" Type:

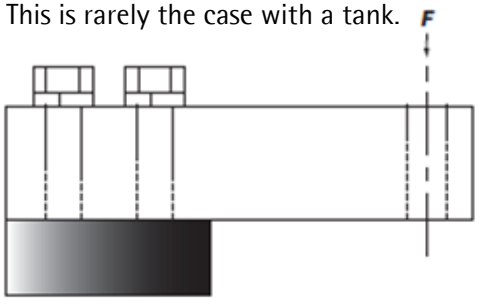
The "S" type has two machined slots that are parallel to each other so that the force will be strait down and no angle will be introduced. There are two types, Compression and Tension. The strain gage is mounted vertically similar to a Shear Beam. If combined with the pivoting mounting kit and floating load introduction "buttons" it can be the most accurate choice for medium capacity tank projects. The tension model is an excellent way to suspended tanks if combined with a swivel mount.

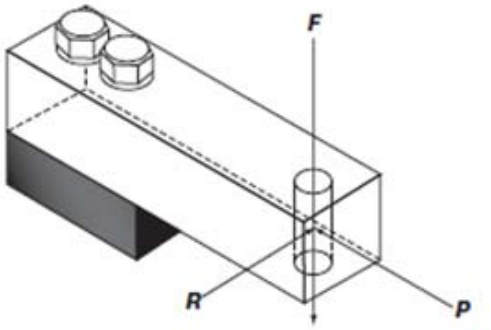
The next question is what kind of load cells should I use for my portable tank project?

Ok, most of us in the weighing business are familiar with beam type cells, and they have the simplest installation, we can look at those first.

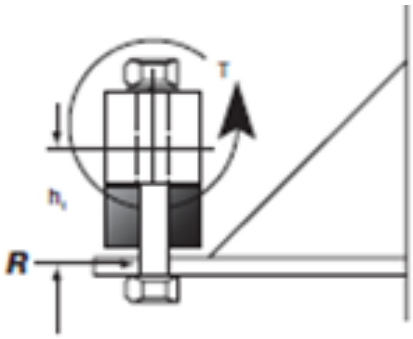
In a perfect world, the tank would be like a scale. The force would be strait down and we would have a perfect measurement, right? This is rarely the case with a tank.



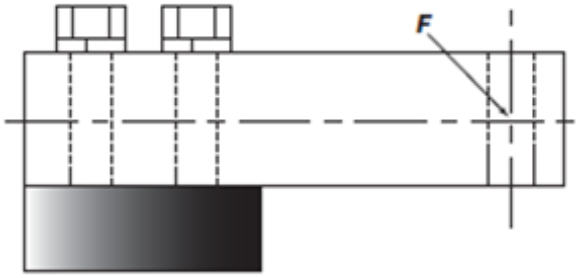
Let's look at some things that can go wrong and spoil the perfect result:



Hopefully the load will be from "F" direction. Suppose there is a thermal expansion between the Frame and the tank? A force "P" or "R" will be exerted on the cell causing the undesired output of the strain gage.



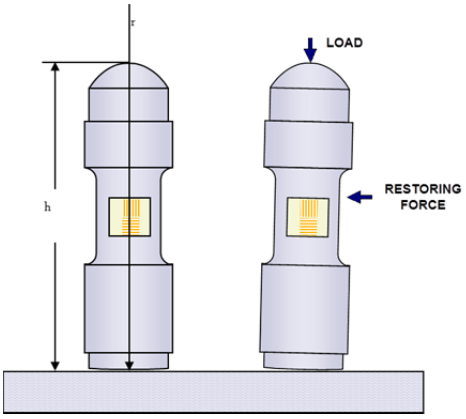
Sometimes when a side load is introduced the effect will be a twisting motion, again causing unwanted output from the strain gage.



If the load is applied at an angle because of imperfect installation or design, the force will be reduced by the cosine error.

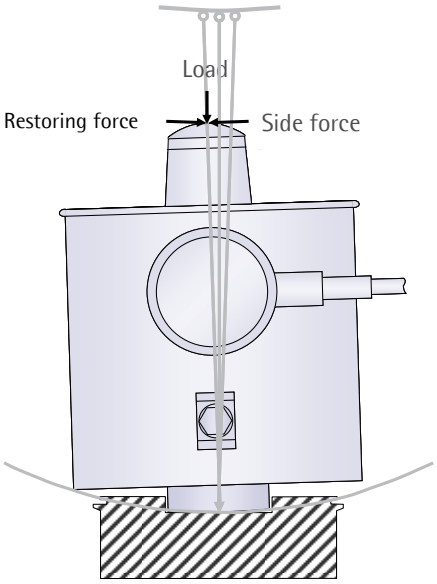
If the tanked is heated or cooled from the ambient or if a mixer or agitator is used some or all of these errors may be seen. What happens if this tank is transported? If the strain gages get stretched during movement, they will develop a "zero shift" This can be dealt with during the dead load adjustment as part of calibration, but eventually the useful range is lost as this effect can accumulate.

Now let's look at a canister type load cell for the portable tank application:

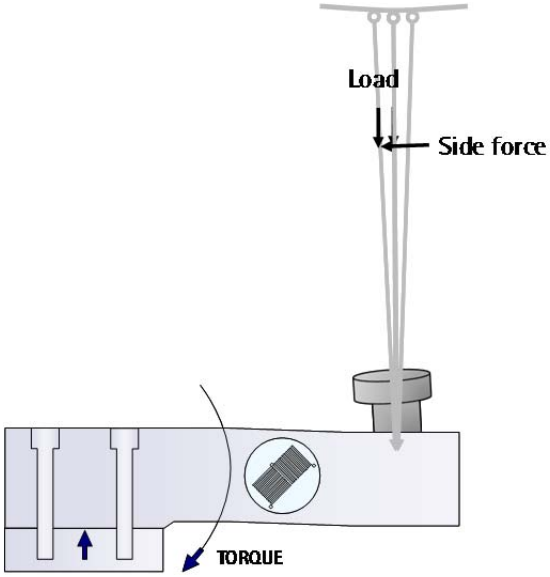


With this type of load cell the load introduction is centered for installations with as much as 2 degrees tilt. These load cells must be mounted in a "mounting kit" that will use constrainers to keep then in place in one direction, but allow the load cell to move in cases of thermal expansion.

Rocker Pin Principle:



Shear Beam Principle:



With the Rocker Pin, side force causes tilt and a restoring force compensates expansion/shear forces with less impact on accuracy. The canister load cell with a spherical element on both top and bottom gives the highest accuracy because it will not transfer side forces or moments.

With the Shear Beam cell, side force causes tilt of the load pin and the restoring force will not be generated. Expansion from mixers and heat can affect accuracy.

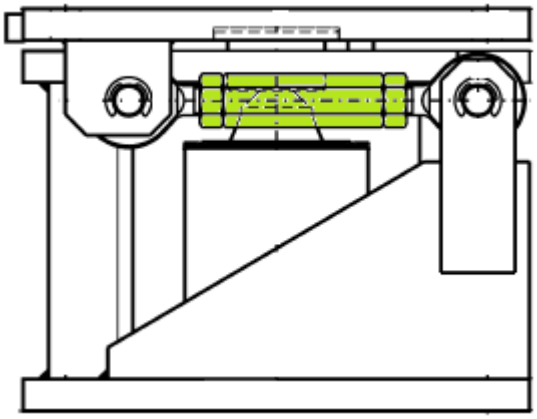
While the canister appears to be preferable for portable tanks because it eliminates errors due to not being hard bolted to the tank or vessel, how do they remain mounted in place?

Mounting Kits:

A good mounting kit needs to keep the load cells upright and also allow movement caused by thermal expansion. The mounting kit should also prevent the tank from tipping over (lift-off).

There must be a mechanism (Constrainer) that prevents side forces from damaging the load cell.

If a load cell needs to be removed it would be nice to have a built-in "jack-up" device. This device also allows the tank to be installed without the load cells. This is important not only to give a solid surface to set the tank on but the load cells can be installed later- after the welding process is complete.

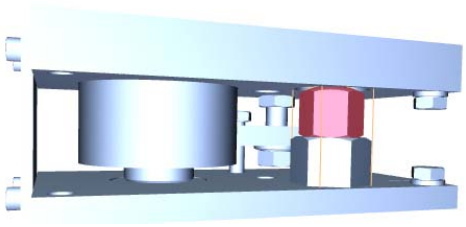


The above load cell/mounting kit combination has all of the features you would want in a tank weighing system, except it may be too big and bulky for portable tank applications.

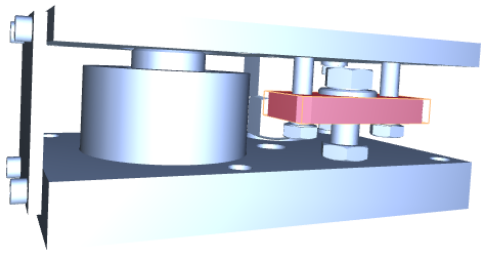
The better choice for Portable Tank Weighing:

Here is a more compact design that incorporates the Lift-off protection feature that prevents a tank from tipping over and Jack-Up mechanism for taking the load off the load cell during transport or for maintenance operations. A constrainer is used to protect the load cell from unwanted horizontal forces.

Low profile is an additional consideration with portable tank systems. It is often necessary to maintain clearance with doorways and low ceilings. This type canister load cell with one spherical element on top gives a high accuracy because it will resist side forces and does not transmit moments.

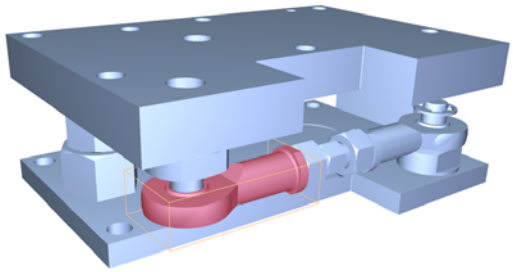


This load cell/mounting kit combination has an integral Jack-Up Mechanism. This allows load cells to be easily removed for maintenance or cleaning and to lift the load off of the cells for long range transport of the system.



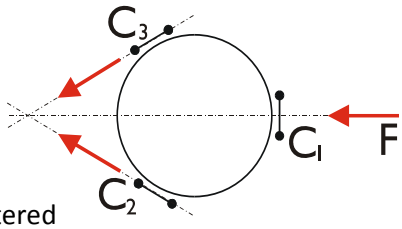
There is also lift-off protection built in, another feature that should always be considered with portable tanks or tanks mounted outside.

Constrainers:

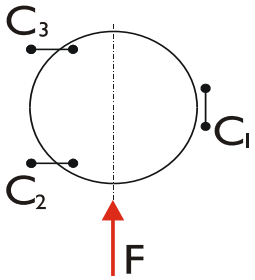


Probably the most important feature on the mounting kit is the constrainer. While the primary goal is to hold the load cell in place and provide protection from side forces, there are ball bearings on each end of the rod that allow the freedom to move or expand. This is important in a process vessel that may have non-uniform thermal characteristics between the upper load structure and lower support structure. This can also help prevent distortions to the structure from agitation or insufficient stiffness from affecting the weighing result. The Constrainer shown above has some adjustment which can be useful in cases where the holes for the mounting kits are not located perfectly.

The direction of the constrainers is important.
With three constrainers under an angle of 120°
external forces from every direction are
at least counteracted by two constrainers.
The vessel position remains fixed.
This is best for most applications, especially in
the case of portable tanks. If the load cells do not stay centered
in the mounting kits, they can bind and cause repeatability problems.



If only forces from one direction are expected,
two constrainers in parallel will work very well, however,
forces from other directions can cause problems.



Here are the points to remember for portable tank applications:

- A strong tubular frame is a must, three load cells are better than four in most cases.
- Beam type load cells can be problematic if there is agitation or exposure to horizontal forces.
- Canister type load cells are best for process vessels where unwanted forces are expected.
- Canister type load cells can operate effectively with up to two degrees of tilt.
- Proper constraining is critical both to protect the load cells and to mitigate unwanted forces.
- Lift-off protection should be incorporated with either Beam type or Canister type load cells.