

# CHOOSING LOAD CELLS FOR TOUGH APPLICATIONS

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## What kind of torture do your load cells have to withstand?

This white paper explains how to choose a load cell that will operate reliably in hostile environments and rugged operating conditions.

Load cells are critical components in all weighing systems where they sense the weight of material in weigh hoppers, other vessels, or processing equipment. In some applications, a load cell may be exposed to a hostile environment with corrosive chemicals, heavy dust, high temperatures, or excessive moisture from washing down equipment with large amounts of liquid. Or the load cell may be exposed to high vibration, unequal loads, or other harsh operating conditions. Such conditions can lead to weighing errors or can even damage the load cell if it hasn't been chosen correctly. To select the right load cell for a demanding application, you need a solid understanding of your environment and operating conditions and what load cell features are best for handling them.

## What makes a tough application

Take a close look at the environment surrounding your weighing system and what operating conditions the system must work in.

- Will the area be extremely dusty?
- Will the weighing system be exposed to temperatures higher than 150°F?
- What are the chemical properties of the material being weighed?
- Will the system be washed down with water or another cleaning liquid? If cleaning chemicals are to be used to wash down the equipment, what are their characteristics?
- Will your wash down method expose the load cell to excessive moisture? Will the liquid be sprayed at high pressure? Will the load cell ever be immersed in liquid during wash down?
- Will the load cells be loaded unequally because of material buildup or other conditions?
- Will the system be subject to shock loading (sudden large loads)?
- Will the weighing system's dead load (the vessel or equipment containing the material) be large in proportion to the live load (the material)?
- Will the system be subject to high vibration from passing vehicles or nearby processing or handling equipment?
- If the weighing system is for processing equipment, will the system be subject to high torque forces from the equipment's motor?

Once you know the conditions your weighing system will face, you're ready to choose a load cell with the right features to not only withstand these conditions but to operate reliably over the long term. The following information explains what load cell features are available to handle your tough application.

## Construction Materials

For help choosing a load cell suited to your demanding requirements, consult an experienced load cell supplier or an independent bulk solids handling consultant. Expect to supply detailed information about the material your weighing system will handle, your operating environment, and what conditions will affect the load cell's operation.

A load cell is essentially a metal element that bends in response to the applied load. This element, which includes strain gauges in a electrical circuit, can be constructed of tool steel, aluminum, or stainless steel.

Tool steel is the most common material for load cells used in dry applications because it provides good performance at a relatively low cost and provides a large capacity range. The tool steel load cell is suitable for both single- and multiple-load-cell (called single- and multiple-point) applications. It's best for dry conditions because moisture can rust tool steel. The most popular tool steel alloy for these load cells is type 4340 because it's easy to machine and can be properly heat-treated. It also springs back to its exact starting position after the applied load is removed, limiting creep (a gradual increase in load cell weight readings when the same load is applied over time) and hysteresis (the difference in two weight readings for the same applied load, with one reading obtained by increasing the load from zero, the other by decreasing the load from the load cell's maximum rated capacity).

Aluminum, the least expensive load cell material, is typically used for load cells in single-point, low-capacity applications. The material isn't suited for wet or chemical environments. Type 2023 aluminum is most popular because, like type 4340 tool steel, it returns to its exact starting position after weighing, thus limiting creep and hysteresis.

The strength and corrosion resistance of type 17-4 PH (prescription hardening) stainless steel - also called grade 630 stainless steel - gives it the best overall performance of any stainless steel derivative for load cells. This alloy is more expensive than tool steel or aluminum but offers the best performance of any material in wet applications (that is, those requiring heavy wash down) and chemically corrosive applications. However, some chemicals can attack the type 17-4 PH alloy. In these applications, one option is to apply a thin coating (from 1.5 to 3 millimeters thick) of epoxy paint to the stainless steel load cell. Another is to choose a load cell made of an alloy steel that can better resist corrosion. For help choosing the right load cell material for a chemical application, consult a chemical resistance chart (many are available on the Internet) and work closely with your load cell supplier.

## **Cables**

The cable that runs from the load cell to the weighing system's controller is also available in different materials to handle harsh operating conditions. Most load cells use a cable with a polyurethane jacket that protects the cable from dust and moisture. Some stainless steel load cells come with a Teflon jacket to handle chemicals or will be used with high-temperature (up to 400°F) load cells. Regardless of your load cell's construction material, if the load cell will be exposed to chemicals or high temperatures, in some cases you can specify that the load cell be manufactured with a Teflon cable.

## **High-Temperature Components**

A load cell is temperature-compensated to give reliable weighing results from 0°F to 150°F. When exposed to temperatures above 175°F, the load cell can give unstable readings or even fail unless you select a unit manufactured to withstand temperatures up to 400°F. A high-temperature load cell can be constructed with a tool steel, aluminum, or stainless steel element but is equipped with high-temperature components, including strain gauges, resistors, wires, solder, cables, and adhesives.

## **Seal Options**

A load cell can be sealed in different ways to protect the internal components from the environment. An environmentally sealed load cell can incorporate one or more of the following sealing methods: a rubber boot that fits over the load cell's strain gauge cavity, a cover glued onto this cavity, or a potted strain gauge cavity filled with material such as a 3M RTV. Any of these methods will protect the load cell's internal components from dust, debris, and moderate moisture such as that caused by splashing water during wash down. However, an environmentally sealed load cell won't be protected from high-pressure liquid cleaning or immersion during heavy wash down.

More protection for chemical applications or heavy wash down is offered by a hermetically sealed load cell. This load cell is typically made of stainless steel because the material is best for withstanding these tough applications. The load cell has a welded cover or sleeve that encapsulates the strain gauge cavity. The cable-entry area on a hermetically sealed load cell also has a welded barrier to prevent moisture from wicking into and shorting out the load cell. While it's more expensive than an environmentally sealed load cell, the hermetically sealed provides long-term solution for this type of application.

A welded seal load cell is for applications that may occasionally expose the load cell to water, but it's not suitable for heavy-wash down applications. The welded seal load cell provides a welded seal for the load cell's internal components and is identical to the hermetically sealed load cell except at the cable-entry area. This area in the welded seal load cell doesn't have a welded barrier. To help protect the cable from moisture, the cable-entry area can be fitted with a conduit adapter so the load cell cable can be run through conduit to further protect it.

## Size

In many tough applications, the load cell can be subject to overloads (caused by overfilling the vessel), minor shock load cells (such as from an outlet gate opening to discharge the entire load at once), excess weight on one side of the vessel (for instance, from material buildup or a motor mounted at one side), or even live and dead load miscalculations. A weighing system with a high dead-load-to-live-load ratio (that is, where the dead load consumes a high proportion of the system's capacity) can also put the load cell at risk because the high dead load reduces the system's weighing resolution and can reduce weighing accuracy. Any of these challenges can result in weighing errors or can damage the load cell. To ensure that your load cell can deliver reliable results under these conditions, it must be sized to withstand the weighing system's maximum live load and the dead load plus an added safety factor.

The simplest way to determine the right load cell size for your application is to add the live load and dead load (typically in pounds) and divide this by the number of load cells in the weighing system. This gives the weight that each load cell will be subjected to when the vessel is loaded to its maximum capacity. You should add 25 percent to the number you calculate for each load cell to provide protection from overfilling, minor shock loads, unequal loads, or other severe loading conditions.

Also be aware that, to provide accurate results, all load cells in a multiple-point weighing system must have the same capacity. Thus even if excess weight is applied only at one load point, all load cells in the system must have a larger capacity to compensate for the excess weight. This will reduce the weighing accuracy, so preventing off-balance loading is often a better solution.

Selecting the right features and size for your load cell is just part of the story. Now you need to install the load cell properly so it can stand up to your demanding conditions.

## Load Cell Installation

Carefully installing the weighing system will help ensure that each load cell delivers accurate, reliable weighing results in your tough application. Make sure that the floor supporting the weighing system (or the ceiling suspending the system) is level and plumb, as well as strong and stable enough to support the system's full load without flexing. You may have to beef up the floor or add heavier support beams to the ceiling before you install the weighing system. The vessel support structure, whether this consists of legs under the vessel or a frame suspending the vessel from the ceiling, should deflect uniformly: typically no more than 0.5 inch under full load. The vessel support plane (at the vessel bottom for a floor-mounted compression-mounted vessel or at the top for a ceiling-suspended tension-mounted vessel shouldn't tilt more than 0.5 degree in response to temporary conditions such as a passing forklift or a change in a nearby vessel's material level. If necessary, you can add bracing to stabilize the vessel's legs or suspension frame.

In some difficult applications, high vibration is transmitted from various sources - passing vehicles or motors on nearby processing or handling equipment - through the floor or ceiling to the weighing vessel. In other applications, large torque loads from a motor (such as a on a mixer supported by load cells) are applied to the vessel. If the vessel isn't properly installed, or if the floor or ceiling isn't stable enough to support the vessel properly, these vibrations and torque forces can cause the vessel to deflect non-uniformly. The deflection can produce inaccurate load cell readings or overload the load cells and damage them. To absorb some of the vibration and torque forces on a vessel with compression-mounted load cells, you can mount isolation pads between each vessel leg and the top of the load cell's mounting assembly. In an application subject to high vibration or torque forces, avoid suspending the weighing vessel from tension-mounted load cells at the ceiling because the forces can cause the vessel to sway, which will prevent accurate weighing and over time can cause the suspension hardware to fail. You can also add support braces between the vessel legs to prevent the vessel from deflecting excessively under load.