FORCE CALIBRATION:

An Alternative Way to Calibrate Medical Patient Scales

How Do Medical Patient Weight Scales Work?

As precision scientific instruments, medical-grade patient weighing scales require periodic maintenance known as calibration. Over the long term, scales that are not properly calibrated cannot produce the consistently accurate weight measurements vital for providing quality patient healthcare.

There are two major classifications of medical patient weight scales — mechanical beam scales and electronic or deflection element (load cell) scales. This discussion will focus on the more popular electronic load cell scales.

Load cells are the devices in a scale base that produce a signal proportional to the weight applied to them. This signal is processed by the scale electronics and displayed on the scale indicator.

Load cells are comprised of a "bending" ("deflective") element coupled with a strain gage that responds to the deflection of the bending element. The electrical resistivity of the strain gage changes as the bending element deflects under load. This change in electrical characteristics is proportional to the weight, or force, on the load cell. The scale's electronics and software process the change in electrical signal to calculate the patient's weight for display on the scale.

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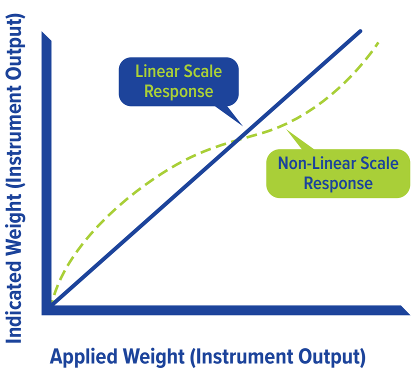
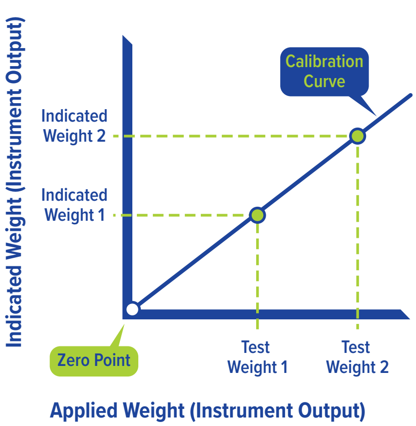
How Are Medical Scales Calibrated?

The current method of medical scale calibration uses certified dead weights. Generally, in electronic scales, the scale calibration routine is embedded in the scale's electronic operating firmware. The calibration function is usually accessible through scale keypad commands.





Scales used in the professional medical market require the calibration technician to apply specific amounts of weight on the scale to complete the calibration procedure. Generally, there is little or no flexibility in the scale firmware to allow for different weight amounts to be substituted in the calibration process.

Most scales will prompt the technician through the calibration process. The basic steps are:

1. **The scale program/firmware collects the instrument output in response to the application of the known weight value(s). The procedure usually requires the application of the calibration weight multiple times to complete the calibration process.**

2. **The firmware makes the necessary correction to the output value to match the known input gathered in step 1 — this is done mathematically in the scale program/firmware and enables the scale to display the correct weight after the calibration process is completed.**

Most common medical scale calibration procedures provide a single point calibration where, along with the scale zero point (no weight on the scale), one weight value is used to establish calibration.

Single point calibration assumes a linear scale response over the operating weight range of the scale (see sidebar diagram re: linearity). Since scale linearity is a characteristic of the instrument design, this is a reasonable assumption for high quality scales in good operating condition that have not been subjected to abuse.

The age of the scale and the amount of use, or load cycles, the scale has experienced, as well as any abuse the instrument has endured, can impact scale linearity and accuracy. These impacts are difficult to qualify or predict due to the vast diversity in scale design as well as the variance in how medical facilities deploy and use their scales. This uncertainty relating to the accuracy and condition of a medical scale is further support for regular calibration as well as full load range testing to verify linearity.

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An Alternate Method of Medical Scale Calibration

Dead weight calibration requires the placement of a significant amount of certified weight on the scale. Often, this weight must be placed and removed multiple times to complete the scale calibration process. Owing to its physically demanding nature, dead weight calibration can be arduous and potentially dangerous to technicians by leading to strain-related injuries.

There is an alternate method of scale calibration that does not require the use of certified dead weights. The **Force Application Method** of scale calibration substitutes an applied mechanical force in place of the test weights since the "weight" measured by a scale is really just a force — the impact of gravity acting on a mass (the certified weights). If an accurately measured force is applied to a scale, the applied force will serve as a direct proxy for the dead weight traditionally used in scale calibration.

Why Does the Force Application Method Work for Scale Calibration?

To understand how the Force Application Method works, we must understand what the term "weight" means. Simply stated, the indicated "weight" on a scale is a measurement of the force of gravity acting on the mass placed on the scale measurement platform. "Weight" is defined more specifically as the amount of force the acceleration of gravity exerts on an object.

Isaac Newton's second law defined the formula for force as:	
$F = ma$	Where: F = force m = mass or the amount of material present a = acceleration acting on the mass

In this discussion, the variable "a" represents the acceleration due to earth's gravity.

Generally speaking, an object on earth with 1 lb. of mass weighs one pound. This means that a 1 lb. mass exerts one pound of force when it rests on a scale, causing the scale to read "1 lb."

If a force is applied to a scale by another device, such as squeezing the platform in a vice or clamp, it will react to the force being applied and display it as weight. If the force being applied by the vice is equal to the force applied by a dead weight, the scale will behave in the exact same manner. This is why the Force Application Method can be used to calibrate a scale. When the force is applied in an accurate manner, the two methods can be considered identical.

Why Hasn't the Force Application Method Been Used for Calibrating Medical Scales?

The Force Application Method has long been used for calibration in large industrial and process weighing systems where obtaining and transporting large enough test weights are impractical. The method has not been used for medical scales where the weights used are smaller and accuracy requirements may be more stringent. These tighter technical requirements present challenges at the lower weight ranges seen in the medical field.

One of these challenges relates to the differences between using a mechanical force to apply pressure to the scale and using gravity to apply the force. We know that depending on where an object is, it will have a different weight. For example, an object with 10 lb. of mass will weigh less on the moon than on the earth or in deep space where it will weigh nothing and be "weightless."

There are also anomalies in the earth's gravitational field across the globe that can affect the force on a dead weight. These anomalies arise because the earth's gravitational field is not completely uniform — for example, an object will "weigh" about 0.5% more at the North and South poles than it does on the equator. The scientific community has specified that the weight of an object will exactly equal its mass when the object is located at sea level and at the latitude of 45 degrees. As the mass is moved away from that point, the gravitational force affecting an object changes, and therefore the force (or "weight") it applies to an object it is resting on also changes.

These fluctuations in gravity are small and generally do not present a problem when calibrating or using a scale, provided the scale is calibrated in a location with a similar local gravity, a very wide area in most applications. For example, a scale calibrated in Chicago and moved to Seattle would see a change of only about 0.05%. If a scale is moved a great enough distance, depending on the application, it may need to be recalibrated.

A Force Application device, on the other hand, is not affected by a change in the earth's gravitational field because it generates force mechanically rather than through force of gravity — as with the example of the vice discussed earlier.

When the Force Application Method is used to calibrate a scale, the device used to apply force needs to generate that force with the appropriate precision. While applying pressure to the scale, the force application device must also account for how the local effect of gravity influences the dead weights in that location.

How Much Is a Scale Affected By Changing Its Location?

The changes in the gravitational field between locations are quite small. For example, if a scale is calibrated in Chicago and then moved to Seattle, Denver or Atlanta, the changes in reading at the new location from changes in the gravitational field would be less than 0.075% (about seven-hundredths of a pound on a 100-pound weight).

The changes in the gravitational field between Chicago and Seattle is

quite small
<0.075%

The Value of Switching to Force-Based Calibration

An accurately applied force, accounting for variations in local gravity, can be a direct substitute for the use of dead weights. Since the **Force Application Method** also eliminates the possible harm that can result in the use of dead weights by technicians, this method becomes all the more valuable when employed as the primary means of ensuring medical-grade patient scales function accurately and consistently.

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