NOVA WEIGH

Tank and Vessel Weighing

TECHNICAL GUIDELINES

"Right First Time" Get It 1st

ISI 9001 Certificate No.FM11445

The information and advice in this booklet is given in good faith and is intended to be used only as a general guide. Nova Weigh accept no responsibility or liability whatsoever for consequences arising from the use of information contained herein.

NOVA **WEIGH**

Technical Guidelines
for
Tank and Vessel Weighing

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INTRODUCTION

At Nova Weigh, our primary aim is to ensure that our weighing systems meet customers' expectations in terms of performance, reliability and, above all , safety. Our range of products and services has been developed and refined through hard-won experience gained over more than two decades.

During this time we have pioneered the design of unique mounting assemblies which form the basis of robust and ultra-reliable weighing systems.

We have shown, time after time, that the formula for accurate weighing systems is based on:

- Well engineered components
- Sound mechanical design and engineering practice
- Well implemented fitting and installation procedures
- Controlled commissioning and calibration routines
- On-going service support and maintenance

These guidelines reflect this philosophy and have been designed as a companion for personnel involved in the design and specification of industrial weighing systems.

They are not intended to provide in-depth engineering design specifications and engineers should always seek expert advice, especially regarding the structural and safety aspects of weighing systems.

The guidelines cover both new and retrofit installations and, although many of the concepts and principles apply to both, a number of key issues are highlighted specifically for retrofit systems.

PLANNING

Planning ahead can pay dividends and save valuable time and resources. We consider the initial concept and design stages of a weighing system to be of paramount importance and actively encourage customers to involve our technical staff from the beginning of any project.

The first step in ensuring a reliable and accurate weighing system is to understand and appreciate the following aspects:

Weighing requirements:

- Basic level control
- Inventory control
- Batching and blending
- Loss-in-weight
- Filling

Materials:

- Liquids (free-flowing)
- Liquids (viscous)
- Powders/Granules
- Solids

Operating conditions:

- Temperature extremes
- Corrosive chemicals
- Hazardous area classification (if applicable)
- Nuclear
- Vibration (mixers, agitators)
- Washdown

Environmental conditions:

- Wind
- Electrical storms
- Seismic
- Rain/Snow/Ice
- Dust

These factors have a major impact on the accuracy and performance that can be expected and it is important that both you, the customer, and Nova Weigh understand and appreciate what is required and expected.

Once these factors have been addressed, it should be possible to obtain a clear picture of how the system will operate and a set of basic design criteria can be established.

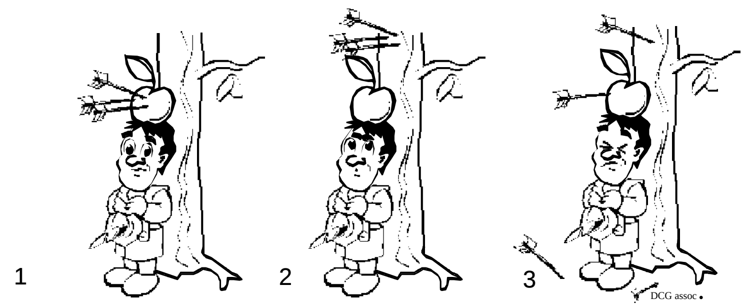
WEIGHING SYSTEM PERFORMANCE

see Calibration page 34

Although a weighing system may be designed to provide the required performance, the installed accuracy will be affected by a number of process and external influences which may significantly affect the actual performance of the system.

For example, when material is being pumped or conveyed into a vessel, factors such as material in flight, impact forces and vibration will affect system performance. External factors such as wind, excessive temperature fluctuations or rain may also contribute to system errors. All these influences must be taken into account when calculating the accuracy of a weighing system. The method used to calibrate the system also has a major effect on achievable performance.

At this stage, it is useful to explain what is meant by terms such as accuracy and repeatability. Often these terms are misunderstood, misused or confused with each other. The relative importance of accuracy and repeatability will depend on how the system is operated and the cartoons below illustrate the differences.



The archer's shots in figure (1) are both repeatable and accurate. In figure (2) they are repeatable but not accurate. Those in figure (3) are neither accurate nor repeatable.

Note. See "Terms and Definitions" for more information.

WEIGHING PRINCIPLES

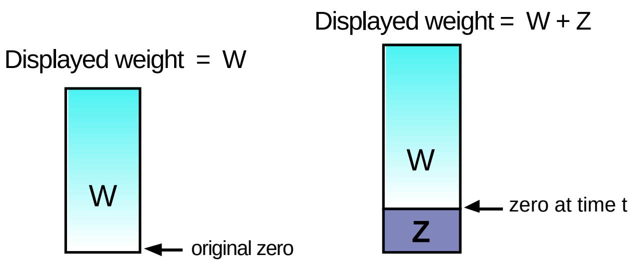
It is important to have a clear understanding of what your weighing system will be used for, and how it will operate.

BASIC INVENTORY AND LEVEL CONTROL (storage vessels)

The installed accuracy requirement for such systems may be modest and this might tempt the user to fit lower specification load cells or instrumentation. In practice, however, this may give unsatisfactory results since the stability of the zero-point compensation of these devices may be poor and they may be subjected to large swings in ambient temperature due to an exposed location.

Storage hoppers or tanks may not be fully emptied for long periods and until they are empty it is not possible to reset a zero point which has changed, for example, due to drift or temperature effects. in the meantime zero-shift will show itself as an error in the indicated contents weight.

A user will not have great confidence in a weighing system which shows a fluctuating weight, for example between day and night, when the actual quantity of material in the vessel has not changed.



BATCHING AND BLENDING SYSTEMS

In these systems, the actual weighing takes place over a much shorter period (typically minutes or hours) and therefore higher accuracy should be achievable than with storage vessels. Before commencing a batch, the system is usually re-zeroed or tared, thus minimising errors due to zero fluctuation.

Normally, the vessel will also be tared out after each ingredient has been added thus further improving performance.

However, remember that the accuracy of each ingredient's weight is dependent not only on the accuracy of the actual system but also on the method of conveying the ingredients into the weighing vessel. This may be via pipes, conveyors or screw feeders. The effectiveness of any control valves or motor controls will directly affect weighing performance. For the user, batch repeatability or consistency may be more important than absolute batch weight accuracy.

Minor additions to a mix will normally be weighed to a much higher absolute accuracy than bulk ingredients.

A recipe may include both bulk and minor ingredients. If the required accuracy for each ingredient, in terms of percentage of its individual weight, is the same then, naturally, this translates into a smaller absolute value in the case of the minor ingredients.

For example, a vessel weighing system with a span of 5000kg may typically be specified with a system accuracy of ± 0.1% of span, equivalent to ± 5kg. If all ingredients require to be batched with a precision of ± 1% of their target weight, the 5kg weighing uncertainty is acceptable in the case of a 1,000kg addition but would be unacceptable in the case of a minor addition of 100kg.

Fortunately, the influences of most errors within a load cell weighing system reduce proportionally and experience shows that, for the given example, a weighing accuracy of 0.5kg-1kg would be achievable. This would meet the recipe requirements without the need for a smaller capacity pre-weigh vessel for the minor additions.

These figures are for general guidance and each application needs individual assessment. In reviewing an application the complete measurement and control loop must be considered and the weakest 'link in the chain' will determine the accuracy.

FUNDAMENTAL DESIGN CONSIDERATIONS

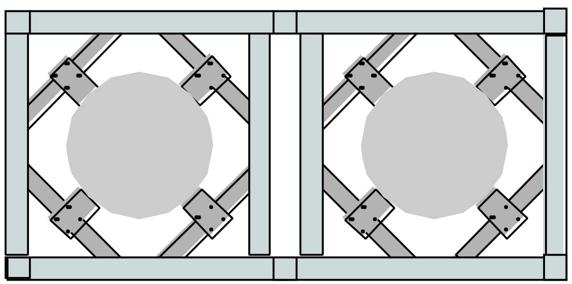
DECIDING ON THE NUMBER OF LOAD CELLS

The number of load cells used in a particular system is normally governed by the design and shape of the weighing vessel in conjunction with the required performance.

If the vessel is supported on legs, then the number of legs determines the number of LoadMounts. Three-legged vessels are easier to mount and equal load distribution is assured. Four-legged vessels are more mechanically stable by a factor of around 30% but usually require more adjustment to ensure that all four load cells see equal loads throughout the weighing range. Vessels with more than four legs need special consideration.

Vessel stability is an important factor for tall vessels especially if installed outdoors in areas of high wind and when the vessel contents do not distribute evenly.

When vessels are mounted on steel support structures, the fundamental design criteria will determine how the vessels are mounted and hence the number of LoadMounts used. The most common arrangement is with four equally spaced support points around the circumference of the vessel as shown below.



PIVOTS

High-accuracy weighing systems dictate the use of LoadMounts at each support point. However, for certain weighing applications, it is possible to use a combination of live LoadMounts and pivots. This can provide a cost-effective solution depending on what is being weighed and the accuracy required.

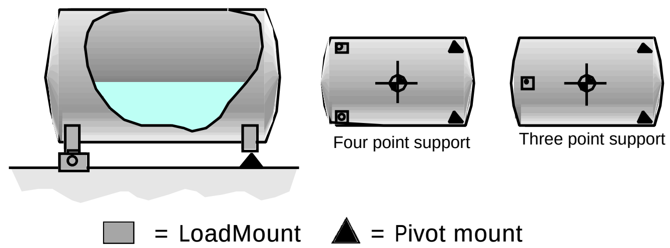
Such systems should not be confused with electromechanical weighing systems which typically use a single load cell at the end of a mechanical beam.

Normally it is only advisable to use pivots in systems which involve the weighing of liquids or free-flowing solids.

Pivots can consist of simple short sections of "I" beam or LoadMounts without load cells. One advantage of using LoadMounts is that such systems can readily be upgraded at a later date, if required.

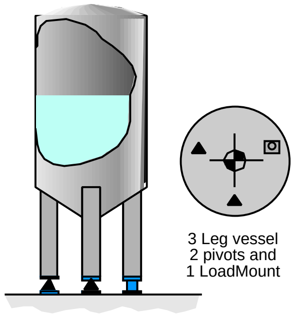
The accuracy of such a system is dependent on how the centre of gravity of the weighing system moves in the horizontal plane as the vessel is filled or emptied. (In other words, how the load is distributed between the load cells and pivots.)

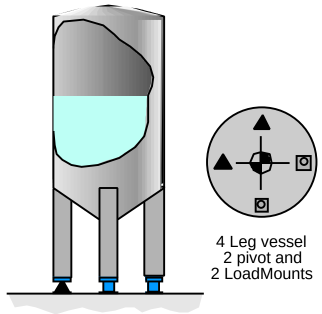
Calibrating weighing systems incorporating pivots needs special consideration. The only effective method is to load the vessel in a manner which duplicates the way in which the vessel is loaded in practice. The most efficient procedure to achieve this is to use the flow meter method.



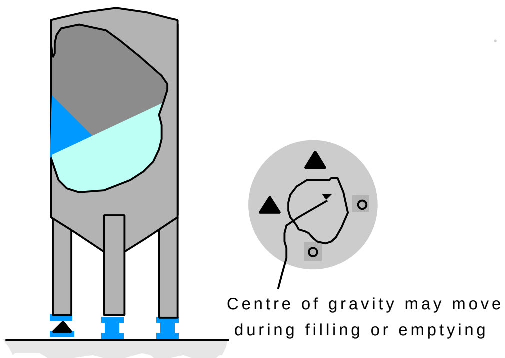
see Calibration page 34

Horizontal tanks containing liquids are ideally suited to the application of pivots. A four-point support will use two pivots and two LoadMounts. A three-point support will use two pivots and one LoadMount.





The above figures show typical examples of vessels containing liquids which incorporate pivots and live LoadMounts. Provided that care is taken in the design, installation and calibration, then acceptable accuracy can be achieved.



In this application it can be seen that the position of the centre of gravity can move considerably as material is added or taken from the vessel. As a result, the use of pivots and live assemblies in these situations would lead to significant errors.

LOADMOUNT POSITIONING

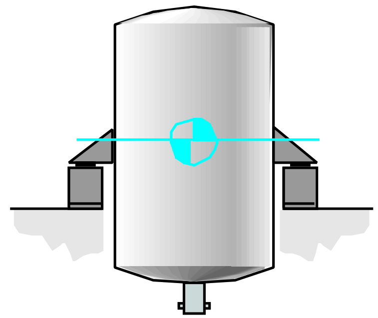
Ideally load cells should be as near as possible to, or above, the centre of gravity of the vessel or tank.

In many cases this may not be practical, especially in retrofit situations. If so, then consideration should be given to the overall integrity of the structure.

If load cells are retrofitted to vessels with long support legs, the LoadMounts should be positioned as close to the top of the legs as possible.

see Mounting page 20

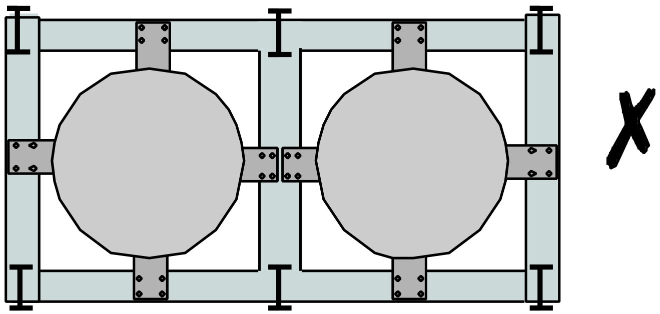
see Retrofit page 18



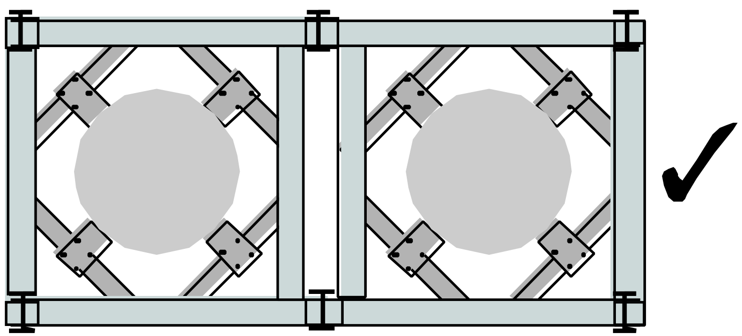
VESSEL INTERACTION

The performance of any weighing system relies on the repeatable linear deflection of the structure above and below the load cells. Any non-linear structural deflection will result in erroneous weight readings.

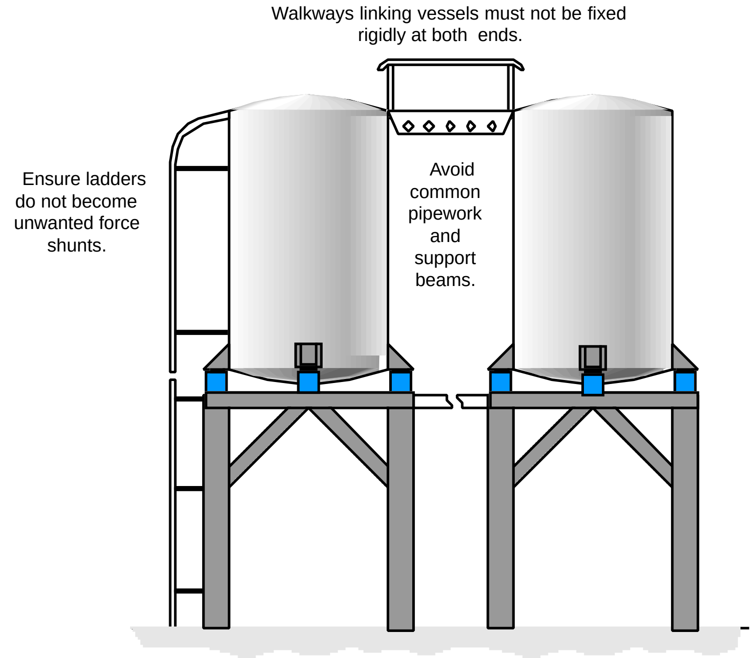
Problems can arise when vessels share one or more common support beams as illustrated below. Load changes in one vessel may affect the output in an adjacent vessel.



The problem can be overcome by using independent supports as shown below. Not only are the vessels now independent of each other but the diagonal support beams are shorter and therefore have lower deflection.



Care should also be taken to ensure that external fittings such as ladders and walkways do not impede vessel movement.



PIPEWORK

Common pipework between vessels can cause errors and should be avoided where possible.

FLOORING

Where vessels are fitted through flooring, sufficient clearance must be given to allow for thermal expansion. (Remember that both the floor and the vessel expand and contract). Flooring must also have sufficient rigidity and strength to support the maximum loads involved.

see Mounting page 20

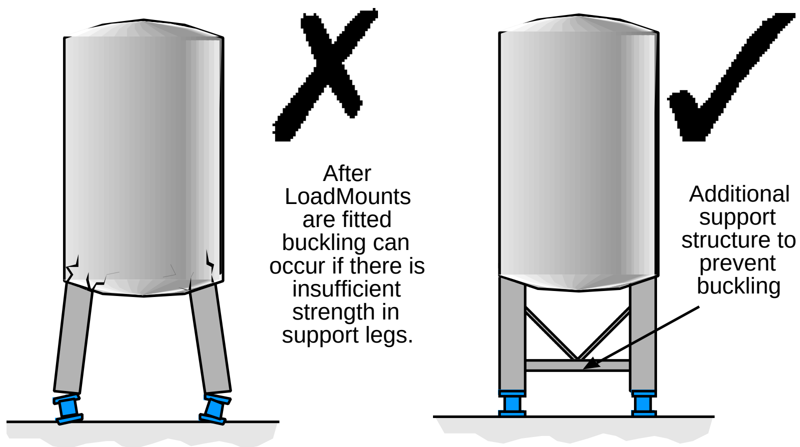
RETROFIT SYSTEMS

When fitting load cells and LoadMounts to existing structures, care must be taken to ensure that the overall mechanical integrity of the structure is not affected.

If existing vessels or tanks are fixed directly to the ground or other structure, the action of un-bolting these and fitting LoadMounts can cause unwanted buckling or distortion when they are subsequently loaded.

Although LoadMounts are designed to control both side movement and lift-off, they must only be used with rigid structures and should never be used as part of the overall mechanical strength design criteria.

The performance and integrity of the LoadMounts rely on the applied load acting vertically down through the primary axis. Unwanted angular or off-centre displacement of the load caused by movement of support legs will introduce errors and in very severe cases can cause load cells to be ejected from their mounts with catastrophic results.



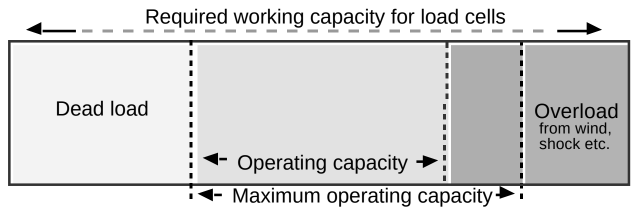
Simple additional cross braces or other stiffening beams will usually prevent this problem arising.

SELECTING LOAD CELL CAPACITY

Choosing the correct load cell capacity for a particular system is very straightforward and there are a number of ways of arriving at a satisfactory answer.

The load cells supporting a vessel must be capable of handling;

- The maximum static load which can be applied.
- Any dynamic or shock load which may occur.
- Additional load from wind or seismic activity.



Although, it may be tempting to over-specify load cell capacity to accommodate every eventuality, this can present problems by reducing the available signal output to an unacceptable level. The load cells must provide adequate signal output (output per unit load) so that the accompanying electronics can process the data within the required accuracy.

All the load cells in a particular system must be of the same capacity and type. They should be located so that they each see similar loads throughout the working range of the system. Ideally the load cell outputs should be balanced to within 0.5-1.0mV.

In most applications, the LoadMounts can be placed symmetrically around the vessel. However, under certain circumstances, the assemblies may need to be placed so that allowance is made for displaced loading which may be caused by such items as motors and mixers.

The optimum position for the LoadMounts can be calculated by taking moments about each loading point in order to calculate load distribution.

see Installation page 34

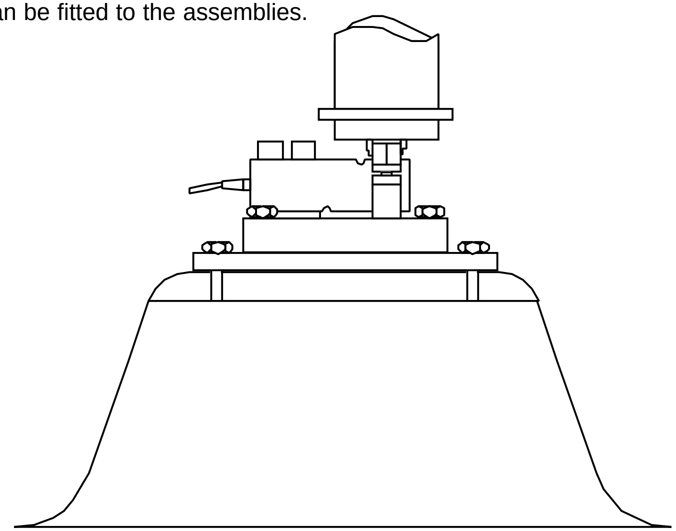
MOUNTING

The correct installation of LoadMounts is the key to trouble-free weighing and optimum performance. Nova Weigh LoadMounts are specifically designed to ensure optimum load introduction but it is vitally important that support structures, groundwork and weighing structures are designed, built and installed to provide level and sufficiently strong support.

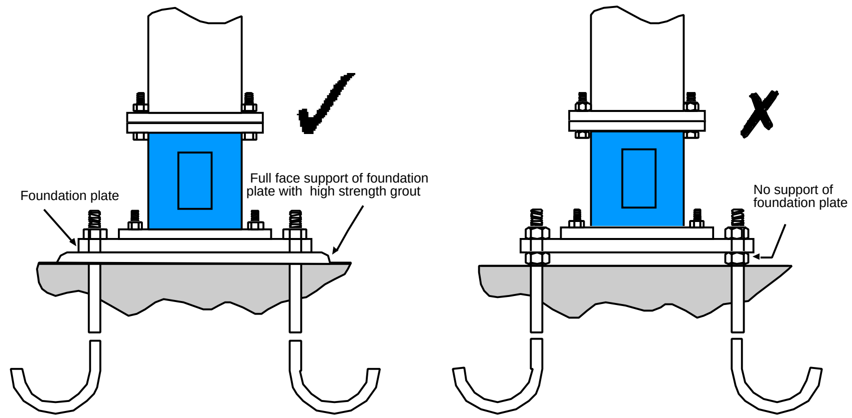
There are typically two positions where load cells are mounted in a vessel weighing system.

CONCRETE BASE WORKS

These must be suitable to support the maximum loads and be as level as practicable.
To facilitate levelling and minimise problems from flooding, the LoadMounts can be fitted to low concrete piers, cast above the main groundworks. Steel base plates are bolted to the top of each pier and finally levelled with grout. The vessel is then lowered onto the piers with dummy LoadMounts (plus additional foundation plates) bolted to the vessel. Once the vessel is located in the correct position, these base plates can be welded to the plates on the piers. This procedure ensures accurate vessel location, avoids problems associated with thread misalignment and saves costly on-site time. When all welding and adjustments have been carried out, the load cells can be fitted to the assemblies.



When grouting support plates ensure that any threaded mounting holes remain clear with sufficient depth clearance to accommodate the bolts used to secure the LoadMounts.



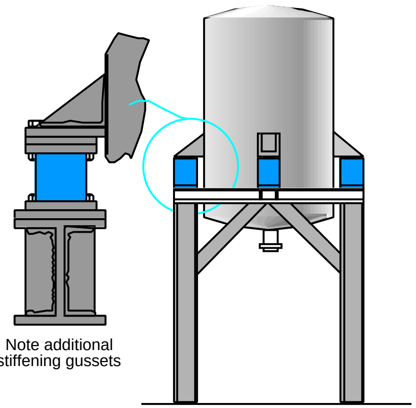
If LoadMounts are fitted directly to the groundworks, it is important to remember that adequate drainage must be provided around the base so that flooding does not occur, leaving the load cells sitting in water.

ON TOP OF THE SUPPORT STRUCTURE

It is important to ensure that the deflections of structural support members are both minimised and equalised under load. Differential deflections will introduce inaccuracies especially in systems with more than three load cells. The support legs must be stiff enough in the horizontal direction to prevent splaying or buckling.

Additional support braces and gussets should be provided as shown opposite.

It should also be remembered that structural deflections will directly affect any attached pipework.



Below, Figure (A) shows how the primary loading axis should be positioned directly through any support beam. This prevents any twisting (see Figure (B) which will adversely affect weighing performance.

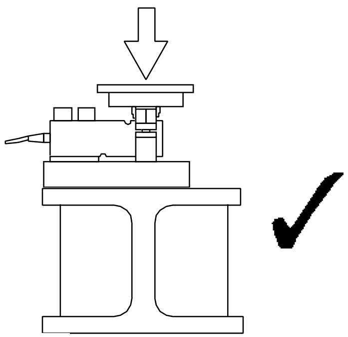


Figure A

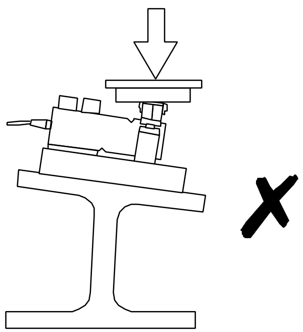


Figure B

FOUNDATION PLATES

Mounting assemblies, such as Nova Weigh's LoadMount range, incorporate a heavy duty base plate and are suitable for direct mounting onto steelwork or concrete. In some cases customers prefer to use additional foundation plates to simplify installation and the benefits include:

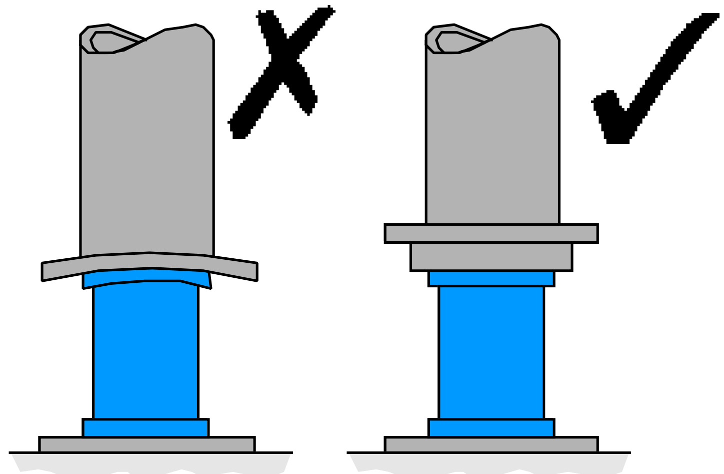
- Avoiding the need for on-site drilling of fixing holes.
- Aids to levelling uneven floors etc.
- Reduction in floor loadings.

These plates should form an integral part of the structure and be welded, bolted or grouted in position as appropriate.

TUBULAR SUPPORT LEGS

When fitting load assemblies to vessels with tubular legs, there must be sufficient strength in their support plates to prevent loading assemblies distorting these plates as shown bellow.

see Retrofit page 18



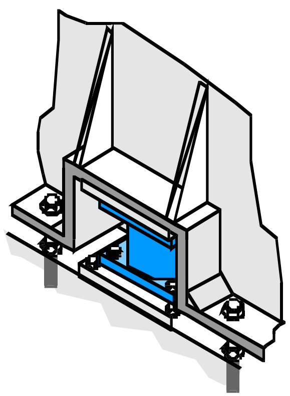
ADDITIONAL RESTRAINTS AND TIE BARS

Although the Nova Weigh LoadMounts are designed to restrain weighing vessels in both the horizontal and vertical direction, for certain applications it may be prudent to fit additional restraints.

This is important when vessels are installed in exposed windy sites, areas prone to seismic activity, or where process activity (vibration, mixers, agitators etc) may cause excessive vessel movement.

LIFT-OFF BOLTS

These are mandatory for vessels subjected to wind or seismic activity. The clearance holes must allow for thermal expansion and other normal structural movement. They must be strong enough to withstand the maximum forces expected and be sufficiently secure in the base works or support structure to avoid any possibility of them lifting out. They should be set to restrain upward movement to prevent damage to load cells caused by return shock loading when vessels return to equilibrium after any overturning force is removed.



Similar protection can be provided with other mechanical configurations.

PIPEWORK

Most vessel weighing applications have various forms of pipework connected to them.

These will act as force shunts and can introduce unwanted errors into the weighing system. It is therefore important that the effect of these is minimised. It should be noted that pipework will tend to have a greater relative effect on low capacity systems when compared with those of higher capacity.

There are two basic effects to consider;

- Effect of pipework on the system stiffness (spring rating).
- Forces introduced by thermal expansion and contraction of pipework.

In principle, well designed pipework systems should have minimal effect on the overall performance of any weighing system. Although the pipework effectively adds stiffness to the overall system, if this is elastic and repeatable, the effect will be compensated for during calibration. However, in practice actual pipework repeatability may be poor - typically in the order of 10%.

In order to maintain the required overall system performance, practice shows that;

$$\text{Total pipe force (kg)} \leq \frac{\text{required system performance (\%)} \times \text{Vessel capacity(kg)}}{10}$$

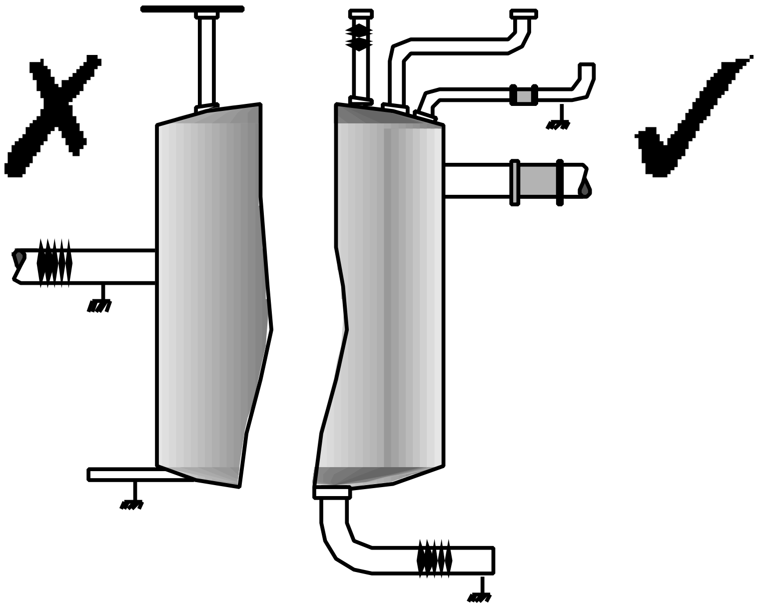
Therefore for a 0.1% weighing system, the total pipe loads should be less than 1% of system capacity and for a 0.05% system, 0.5% of system capacity.

The total pipe force contribution for any system can be calculated knowing the individual pipe and flexible coupling spring ratings. Further information is available on request.

PIPEWORK EXPANSION

If pipework carries hot liquids (either process media or hot water for heating jackets) then its expansion will be greater than that due to normal ambient changes.

This expansion will be in opposition to the vessel expansion and therefore methods of accommodating expansion must be adequate to cope with these total thermal changes.



GOOD PRACTICE

There are several ways of reducing the effect of pipework:

1. Try to balance pipework distribution around a vessel or from side to side.
2. Fit long unsupported pipe runs. Right-angle elbows will reduce stiffness and also accommodate thermal movement.
3. Fit bellows or other flexible couplings to reduce spring rating.
4. Ensure that any pipe supports are not fitted on the vessel side of such elbows or flexible couplings.
5. Try to avoid common pipework between vessels. If these are fitted, ensure that weight change in one vessel cannot cause erroneous weight change in the other.
6. Avoid fixing pipework to floors or ceiling that are subject to random deflections.
7. Remember that electrical conduit or cable trays fitted to the vessel can cause similar problems to process pipework.
8. Ensure good alignment of pipe flanges and other couplings. Do not force connections during installation.
9. If insulation is fitted to the pipework, ensure that this does not introduce additional stiffness problems.
10. Remember that commissioning and calibration must be carried out with all pipework and insulation connected.

TEMPERATURE

Temperature is one of the most important factors to consider when installing systems.

The main effects are:

- Expansion/contraction
- Effects of force shunts
- Effects on components
- Effect on performance - differential heating

Considerable forces, as a result of thermal changes, can be generated if structures are restricted from moving and therefore care must be exercised when designing and installing your weighing system.

Simple calculations show that the comparative dimensional changes for common structural materials per 25ºC temperature change are:

Material	Length change/metre/25ºC
Structural steel	0.3mm
Stainless steel	0.3-0.4mm
Concrete	0.2-0.35mm
Copper	0.4mm
Aluminium	0.6mm
Polycarbonate	1.6mm
PVC	1.9mm

Therefore, for example, a four metre diameter aluminium vessel will change its diameter by approximately 5mm over a temperature range from -10ºC to +40ºC.

see Retrofit page 18

PERFORMANCE

Great care is taken during manufacture to ensure our load cells are fully temperature-compensated and, in practice, performance should not be adversely affected over normal working temperature ranges. However, in certain applications care should be taken to protect the loading assemblies from direct heat sources especially if differential heating can occur.

Rapid temperature changes (>5°C per hour) can also cause problems and in such installations simple insulation procedures will usually remedy the situation.

WIND FORCES

Wind can have significant impact on outdoor weighing vessels. The main effects to consider are:

- System integrity and safety
- System performance
- Load cell damage

The overall forces generated are affected by geographical location, local topography, vessel shape and adjacent buildings. The effects of these forces on the weighing system will depend on wind direction, to what extent the vessel is loaded and the height of its centre of gravity above the LoadMounts.

Winds rarely blow with a steady velocity and gusts often do the most damage. The wind effects on multiple vessel applications are especially difficult to predict.

It is assumed in this booklet that the structure of the weighing system itself and any foundations are capable of withstanding the maximum wind forces to be encountered. If load cells are retrofitted to outdoor vessels care must be exercised to ensure the structure will have sufficient strength <u>after</u> the loading assemblies have been fitted.

Wind forces have two basic components. One component is in the direction of the wind which will tend to exert an overturning moment on the vessel about one or more loading assemblies and a smaller vertical component. Note that this horizontal force will also exert a shearing force on the LoadMounts.

Therefore, these structures must be capable of :

- Supporting the maximum load of the vessel (dead weight + maximum capacity).
- Counteracting the maximum overturning forces caused by the maximum wind velocity.
- Withstanding the horizontal shearing forces.

Maximum wind speed and direction information is usually available from official sources for particular geographic areas. BS 6399 provides this data for the UK.

HORIZONTAL FORCES

The horizontal force (newtons) generated by the wind is given by :

$$F_H = kAv^2$$

where:k is a constant.
A is the exposed cross sectional area of the vessel in m^2.
v is the wind velocity in ms^{-1}

k will vary depending on vessel shape (cylindrical, square etc.) and surface finish, but typically has a value between 0.6 and 0.8.

This horizontal force will cause an overturning moment given by;

$$F_{OT} = F_H \times \frac{h}{d}$$

where : h is the height of the acting centre of wind pressure above the load cells.
d is the distance between the load cells in the direction of the wind.

The exact position where F_H acts can be difficult to compute. For a tall skirted vessel it is reasonable to assume that h is approximately half the height of the vessel.

Substituting for F_H, the overturning force (converted to kg) is given by:

$$F_{OT} = \frac{kAV^2h}{d \times 9.81} \text{ kg}$$

It is important to note that the horizontal force is proportional to the square of the wind speed and therefore increases rapidly as the wind speed increases.

In certain exposed sites the published wind speed may increase by a factor of two.

Detailed information of wind force calculations is available on request.

VERTICAL FORCES

The magnitude of the vertical forces generated as a result of wind will depend on vessel shape and direction. Typically this force will be no more than 5% of the horizontal force. Any uplift force will result in a reduction of the actual displayed weight.

SEISMIC ACTIVITY

Seismic activity refers to movements in the earth's surface resulting from events which include earthquakes, earth tremors and subsidence caused by mining or natural occurrences.

It is clear that significant damage can be caused to weighing systems fitted in known areas of seismic activity and their design must be such that there is minimal risk of component or complete system failure.

Calculating the forces involved is a complex matter and expert advice should be sought. Note that it may be necessary to meet statutory requirements depending on where a system is installed. Even in countries not recognised as areas of high seismic activity, minor earthquakes take place and installations in critical fields such as the nuclear industry may need to meet requirements for seismic loading.

ELECTRICAL STORMS

Electrical storms can cause serious damage to weighing system components.Tall outside vessels are particularly at risk, providing excellent targets for lightning strikes.

Ensuring full protection against damage is very difficult but there are proprietary protection kits available together with advice on minimising problems.

Additional guidelines are;

- Ensure good earthing. The top and bottom of each and every loading assembly in an installation should share a common earth.
- Fit earth bonding straps between the top and bottom of the assemblies.
- Prevent build up of material around the load cell and assembly which may act as a current path, especially in wet conditions.

ELECTRICAL INTERFERENCE

It should be noted that electrical fields from process equipment such as mixers, drives or induction furnaces can cause significant problems with weighing system performance. Therefore, load cell cabling must not be run near any cables supplying power to such equipment.

HAZARDOUS AREAS

Many process weighing applications take place in areas designated as hazardous. These are areas where sparks or heat sources may, under certain conditions, cause an explosion. The subject of fitting equipment in hazardous areas is complex and expert advice should be sought to ensure equipment meets statutory requirements.

Areas are classified into Zones with reference to the risk of a potentially explosive gas/air or dust/air mixture occurring.

Area classification

	HAZARD	>1000 HRS PER YR	10-1000 HRS PER YR	< 10 HRS PER YR
IEC/CENELEC (EUROPE)	GASES	ZONE 0	ZONE 1	ZONE 2
	DUSTS	ZONE 20	ZONE 21	ZONE 22
NORTHAMERICA	DUSTS & GASES	DIVISION 1		DIVISION 2

There are a number of methods used for protecting equipment in hazardous areas. Essentially load cells are non-energy-storing devices and the most common method of protection is that of Intrinsic Safety. This is a technique which achieves safety by limiting the electrical spark energy and surface temperature to levels that are insufficient to ignite an explosive atmosphere in hazardous areas. Nova Weigh can supply load cells certified to EEx ia IIC T6 which, when used with appropriate zener barrier systems, can be installed in all zones for all gas (or dust) classifications.

Note that zener barriers reduce the supply voltage to load cells and hence the millivolt output. Therefore, in such applications, it is important to calculate the optimum load cell capacity to ensure that sufficient output per unit load is available to meet performance criteria.

INSTALLATION AND COMMISSIONING

STORAGE

Load cells should be stored safely prior to fitting. Remember that higher capacity units can be heavy and note should be taken of statutory lifting regulations.

Load cells should **never** be carried by their cables.

FITTING

The Nova Weigh LoadMounts are designed so that they can be fitted to the weighing system without their load cells.

This allows levelling and alignment procedures to be carried out without any risk of damaging the load cells. It is also safe to carry out any final welding at this stage.

Although our LoadMounts provide built-in mechanical protection, for certain applications it may be prudent to fit additional protection.

Load cell cables should be protected by either flexible or rigid conduit. Cutting cables should be avoided as this may affect performance.

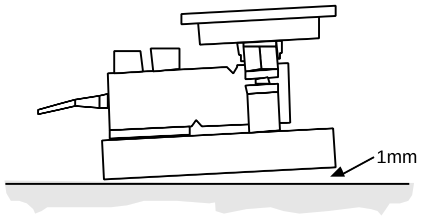
Once the LoadMounts have been fitted in their locked position, it is then straightforward to fit the load cells. (Any built-in jacking bolts are designed to support the fully loaded vessel, but they should not be used to lift or lower a filled vessel.)

LoadMounts are designed to restrain vessels and tanks while still allowing accurate weighing. The units provide sufficient horizontal freedom to accommodate structural changes due to temperature fluctuations. However, huge forces can be exerted if movement is limited either by wrongly positioned LoadMounts, structural members or pipework.

When fitting LoadMounts, note should be taken of the ambient temperature in relation to the maximum and minimum temperatures which will be encountered by the weighing system. Allowance can be made so that the free movement of the LoadMounts comfortably provides sufficient unrestricted movement over this temperature range. This is particularly important if differential expansion and contraction can take place.

LEVELLING

It is important that the LoadMounts are levelled to ensure optimum performance. Our experience shows the longest edges of the base plate should be levelled within 1mm.



LOAD DISTRIBUTION

All the load cells in a system must carry similar loads when the vessel is symmetrically loaded.
In a three-load cell system, the loading is always statically defined so that, even if one load support is not exactly in the same horizontal plane as the other or deflects differently under load, all three load cells will still support the total load. However, in systems with four or more load cells it is usually necessary to carry out adjustments to the level of one or more of the loading assemblies during commissioning.

In order to check the initial load distribution the outputs from each load cell are measured accurately and compared. In a typical system these should differ not more than 10%, preferably less (typically between 0.5 and 1.0mV.) If one or more load cells show deviations greater than this, then the reason should be investigated. It may be due to offset motors or mixers. Where practical the load distribution should be equalised by fitting metal shims between the top of one or more LoadMounts and their vessel support.

Note that such adjustments should be carried out after all pipe work has been fitted and the vessel loaded and unloaded at least once (if this is practicable). Care taken during the initial levelling and installation procedures will minimise the problems caused by unequal load distribution.

WELDING

Electric welding should never be carried out near load cells or instrumentation. The strong electric currents can cause permanent damage and therefore any welding should be completed before the load cells are fitted.

CALIBRATION

The initial overall performance of any weighing system is related directly to the method and effectiveness of calibrating the system during commissioning. It is at this stage that the output from the load cells is related to actual applied load. There are several recognised methods each with its own advantages and uncertainties of measurement.

Before carrying out the initial calibration set up, the system should be fully loaded and unloaded at least once to ensure all parts are fully bedded in.

Remember that ISO requirements specify that the calibration accuracy (uncertainty of measurement) must be better than the required system accuracy by at least a factor of three. Thus the chosen calibration method effectively determines the best overall system performance that can be achieved at the outset. Depending on the design of the weighing system, certain calibration methods may not be applicable and this will in turn affect the achievable accuracy.

Method of calibration	Uncertainty of calibration load	Best attainable system accuracy
Standard weights	± 0.005 - 0.05%	± 0.015 - 0.15%
Reference weights	Typically ± 0.025%	± 0.075%
Substitute material	± 0.025%	± 0.075%
Force transfer method	± 0.05%	± 0.15%
Metered flow	± 0.03%	± 0.1%
Proving tanks	± 0.15%	± 0.5%

Table by kind permission of Institute of Measurement and Control.

It is important to ascertain which calibration method will be used at the preliminary design stage so that the calibration procedure can be accomplished effectively. This may for instance, require additional mechanical supports or hanging points for attaching deadweights. For special applications, Nova Weigh can design a built-in calibration facility for use with special verification load cells. This is particularly useful in high capacity applications where applying sufficient calibration load is very difficult. If calibration by flow meter is to be the preferred method then provision must be made for an adequate supply of water and a method of disposing of this on site.

Any calibration procedure should be capable of loading the system in steps of up to at least 80% (ideally 100%) of the working capacity. If systems are only calibrated over part of their range, extrapolation of results from the lower calibration range can lead to significant errors especially if systems have pipework and other force shunts.

PREVENTATIVE MAINTENANCE

Although our loading assemblies and load cells are designed for long term use in harsh environments, routine preventative maintenance will help to avoid unwanted breakdowns.

Regular inspection of the assemblies and cables can highlight possible problem areas such as build-up of process material, localised flooding or leaking pipes.

Simple cleaning procedures can often prevent problems before they happen and it is important to rectify any process leakages or poor drainage. Cables should be inspected for damage on a regular basis.

The required interval between checks will depend on local operational and environmental conditions, but a minimum should be every six months.

TERMS AND DEFINITIONS (REFER to drawings on page 39)

Accuracy of measurement: the closeness of the agreement between the result of a load measurement and the true value of the load.

Calibration: the set of operations which establish, under specified conditions, the relationship between the values of load applied and the corresponding value of the weighing system output.

Calibration Certificate: a formal and structured document reporting the results of calibration and, where appropriate, relevant findings and observations.

Capacity, minimum operating: value of load applied to the load receiving element, below which the weighing results may be subject to an excessive relative error.

Capacity, rated: the maximum load specified by the manufacturer that can be applied to the load receiving element.

Combined error, (Best straight line): the maximum deviation of weighing system output obtained for increasing and decreasing applied loads, from a 'best fit' straight line passing through zero applied load, computed using the method of least squares.

Combined error, (Terminal): the maximum deviation of weighing system output, obtained for increasing and decreasing applied loads, from the line drawn between zero applied load and maximum applied load.

Creep: the change in weighing system output occurring with time, while under constant load, with all environmental and other influence quantities remaining.

Dead load: the fixed weight of the weighing structure supported by the load cells.

Drift: the slow variation with time of the output of the weighing system with all other influence quantities remaining constant. This term should not be confused with **creep.**

Dummy load cell: a load support which does not contribute to the output of the weighing system. A dummy load cell is not necessarily a permanent part of the installation, cf. **Pivot.**

Force shunt: mechanical interference between a weighing structure and its support structure such as pipework and tie rods.

Hysteresis: the difference between the measurements of weighing system output for the same applied load, one output being obtained by increasing the load from zero load, the other by decreasing the load from the maximum applied load.

In-flight material: additional material being supplied to or taken from a weighing system after an action is taken to stop the flow.

Non-linearity (increasing), best straight line: the deviation of weighing system output, obtained for increasing applied loads from a 'best fit' straight line passing through zero applied load, computed using the method of least squares.

Non-linearity (increasing), terminal: the deviation of weighing system output, obtained for increasing loads, from the line drawn between zero and maximum applied load.

Reference weight: an object of any shape or density calibrated against standard weights.

Resolution: the smallest change in weighing system output that can be meaningfully distinguished.

Re-validation: a test performed on the weighing system to verify its performance at specified load(s).

Span: the difference between the maximum operating capacity and the zero live load.

Standard weight: weight which complies with the appropriate recommendations of the International Organisation of Legal Metrology (OIML).

Tare, n: the weight of a transport container which may be required to be subtracted from the gross weight.

Tare, v: 1) to weigh in order to ascertain the tare
2) the action of adjusting out the weight of a container and/ or its contents, so that the weighing system output represents net weight directly.

Temperature effect on span: the change of weighing system span for a specified change of temperature at steady state conditions.

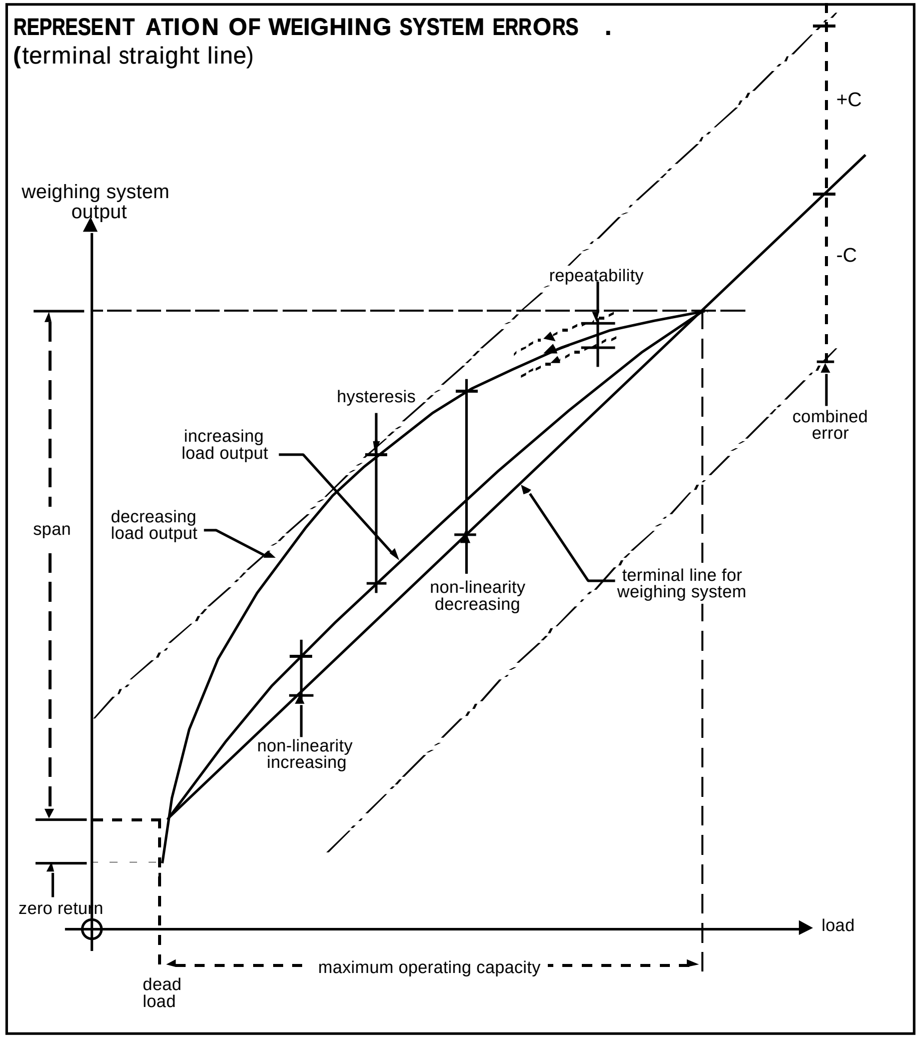
Pivot: an element of a weighing system which supports load but does not itself contribute to the output, cf. **Dummy load cell.**

Repeatability: the measure of agreement between the results of successive measurements of weighing system output for repeated applications of a given calibration load in the same direction.

Temperature effect on zero live load: the change of zero live load output for a specified change of temperature at steady state conditions.

Zero tracking device: device for automatically maintaining the weighing system output at zero within specified limits.

Zero stability: the measure to which the weighing system maintains its output reading over a specified period of time at constant temperature and at zero load.



Terms and definitions from `Code of Practice for the Calibration of Process Weighing Systems'courtesy of Institute of Measurement and Control Document WGC0496.