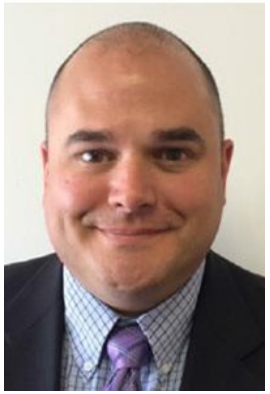
Thank You for Attending Today's Webinar

Your Host

Mike DeLacluyse
President
Lesman Instrument Company
miked@lesman.com



Today's Featured Speaker

James Heaphy
National Sales Manager
Sartorius Intec
james.heaphy@sartorius-intec.com

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Load Cell Basics
Tank & Hopper Training

Jim Heaphy

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Types of Load Cells

Canister

S Type

Compression

Shear Beam

Specialty

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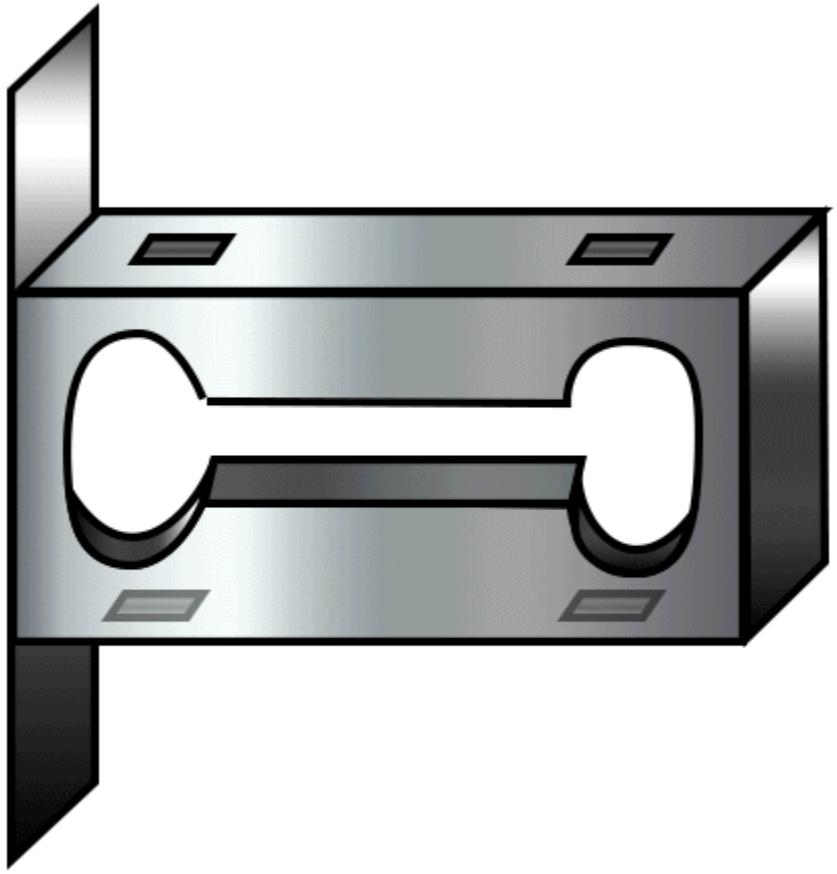
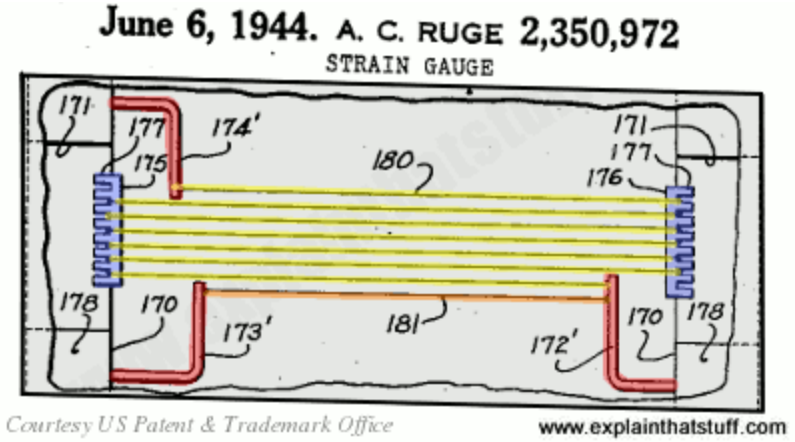
Strain Gauge Load Cell



Electrical Strain Gauge

Arthur Claude Ruge

Ruge had a Eureka moment on April 3, 1938 when "the invention just popped into my mind, whole. I could see it clearly and knew that it would work." His solution was to glue a piece of cigarette paper on the tank and glue a small wire with end connections to the paper [4]. Ruge and his assistants quickly developed this rudimentary device into the more advanced version that would later be patented.

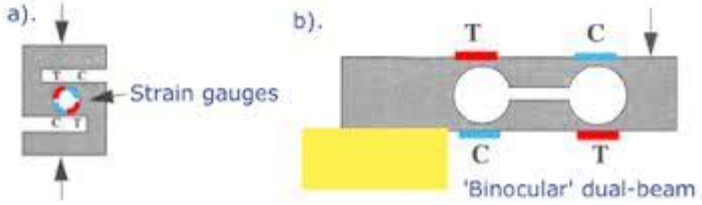


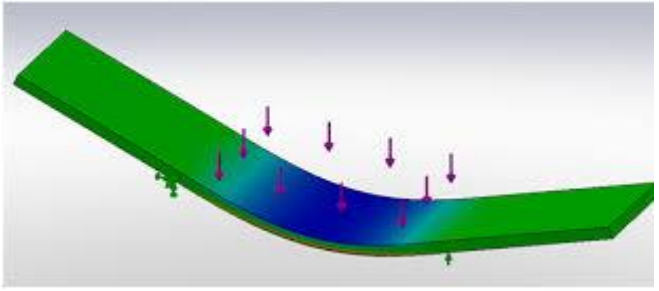
Stress and Strain

Are you stressed? Can you feel the strain? When we talk about "stress" and "strain" in everyday life, we use the two words interchangeably. But in science and engineering, these two words have very precise and very different meanings:

- **Stress**

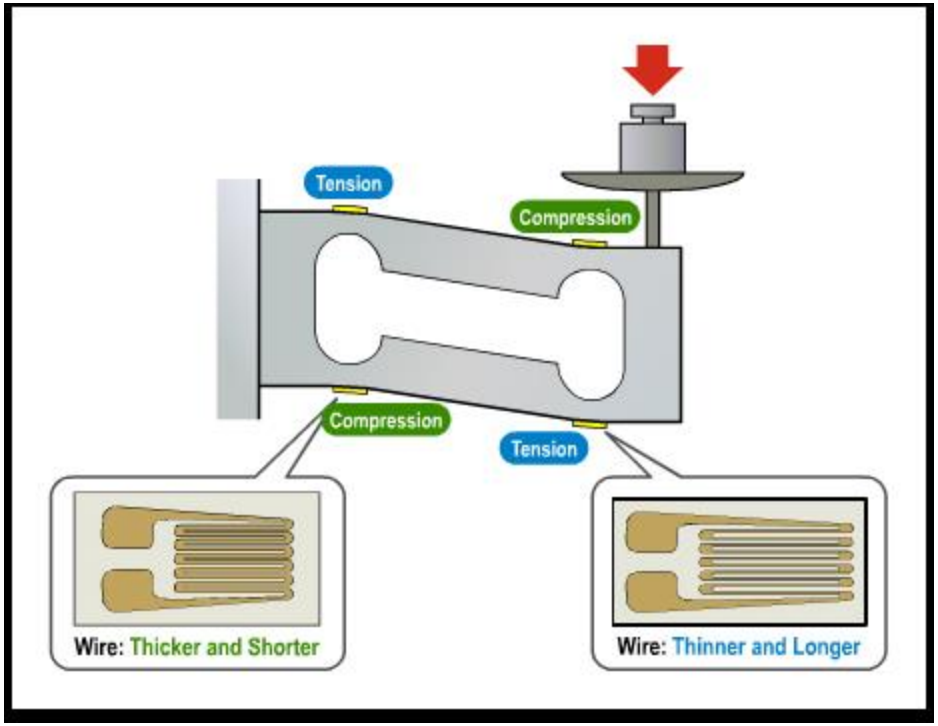
- **Strain**





Strain Gauge Connections

A load cell is a physical element (or transducer if you want to be technical) that can translate pressure (force) into an electrical signal.



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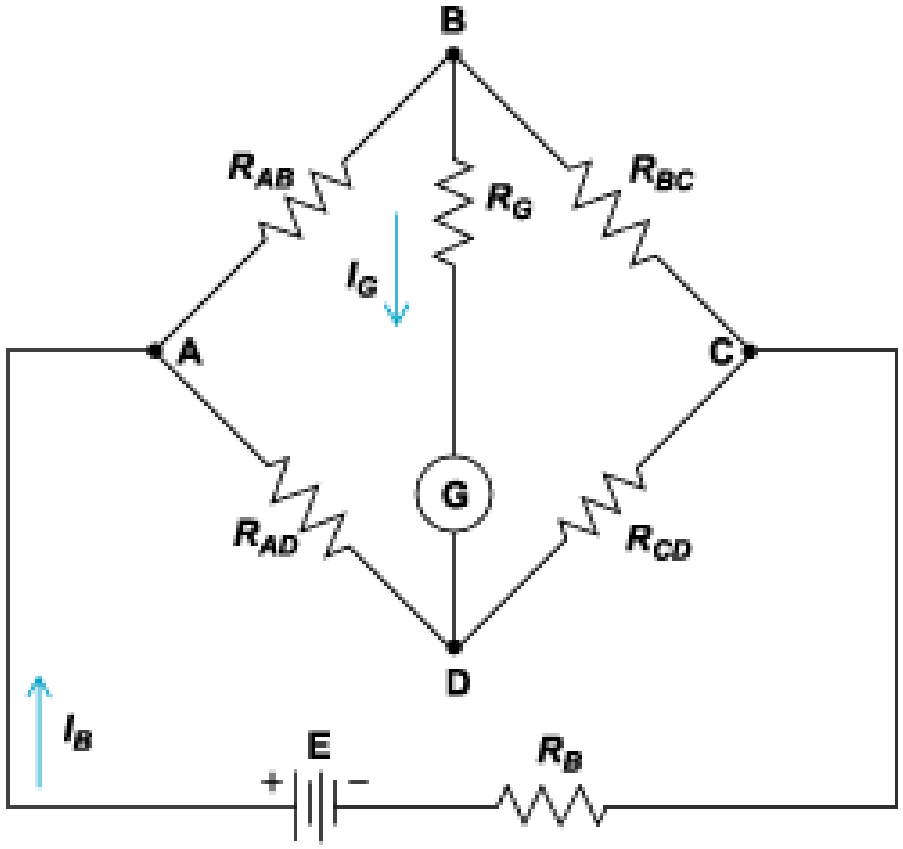
Wheatstone Bridge Circuit



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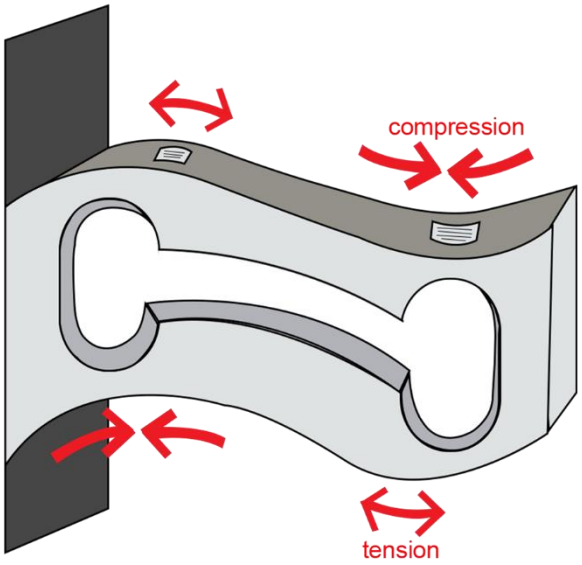
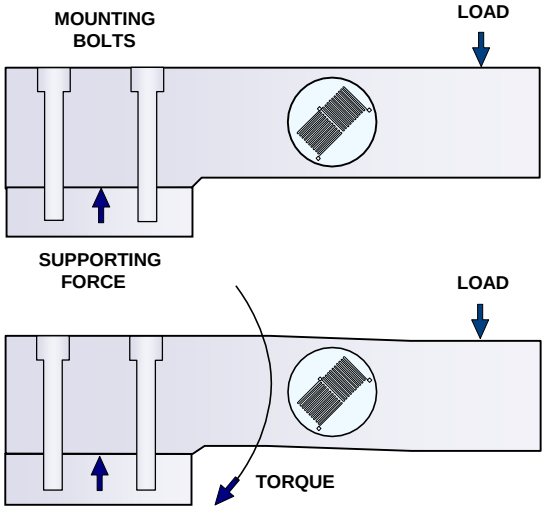
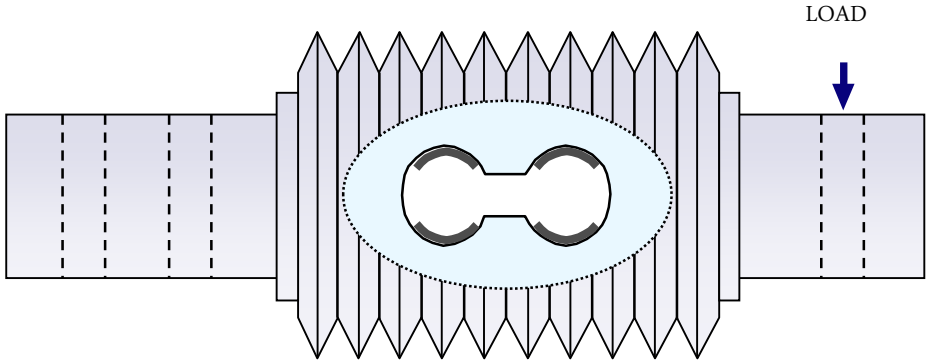
Sheer Beam





Elastic deformation due to applied force.
Attention! The torque moment is not negligible.

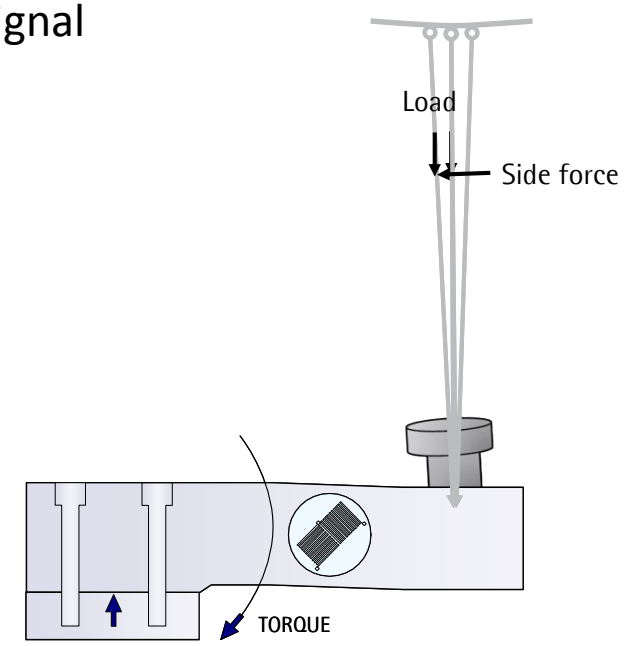


Advantages of sheer beams and bending beams

- Low cost
- Can be used as a structural member of the scale
- Works well in floor scales and bench scales

Disadvantages of sheer beams and bending beams

- All torque in any direction is converted into signal



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Sheer beam design is “good” – but not good enough for a tank

- All cells have a slightly different output – if the tank has side load, the output will change because the cells are not matched – If a cell is replaced, the system must be recalibrated

- Junction boxes require trim pots to balance the load – this adds a weakness to moisture causing frequent maintenance

- Every calibration is unique and must be done by spanning a mass – If a cell is replaced, the system must be recalibrated

- Not optimized for resistance to creep (inconsistent metallurgy) – tanks have constant load – not like a bench scale that is loaded and unloaded
- Not optimized for drift (inconsistent gages) – lower mV/V output cells create less heat and better bonding is required for higher precision

- Temperature compensation is limited

Tank cells and mounts need to meet a higher standard

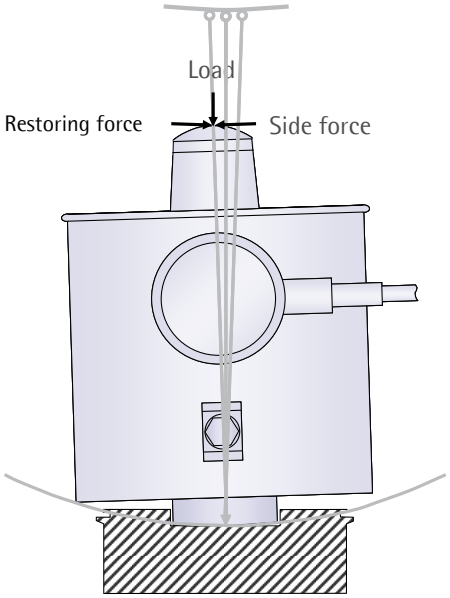
- Tanks are often difficult to calibrate with a mass
- Tanks face motion, side load, temperature swings and require exceptional linearity and resistance to creep
- Tanks are often called on to offer higher precision
- Tanks used in processing can cause tremendous financial loss when there is a failure

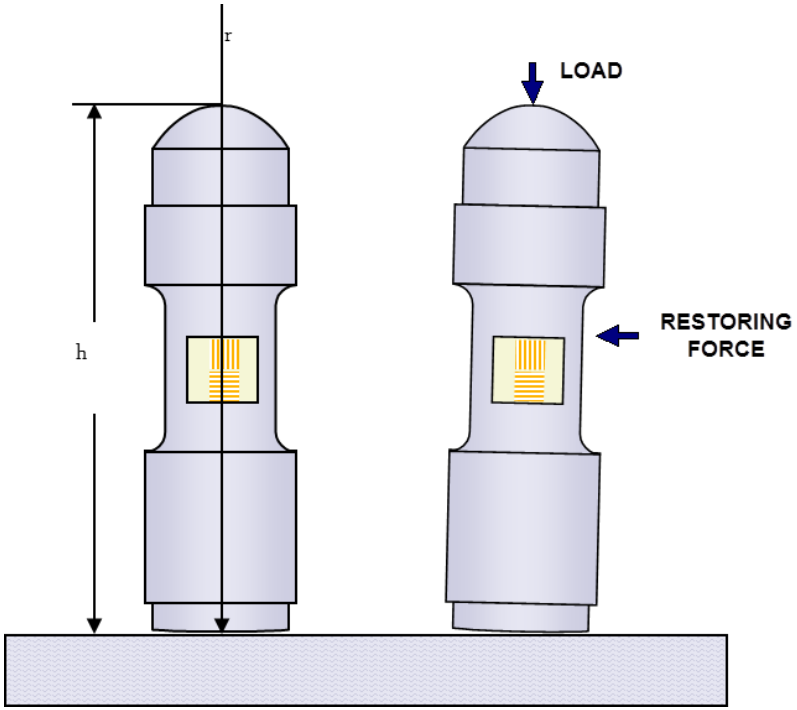
Sheer beams are good for use in tank and silo weighing when:

- The product has low value so low precision is not needed
- The time lost in production has no value and the several day wait for a new load cell installation with calibration with a mass is not an issue

Design

- Off center loads should travel through the beam exactly through the center without causing a change in load cell output

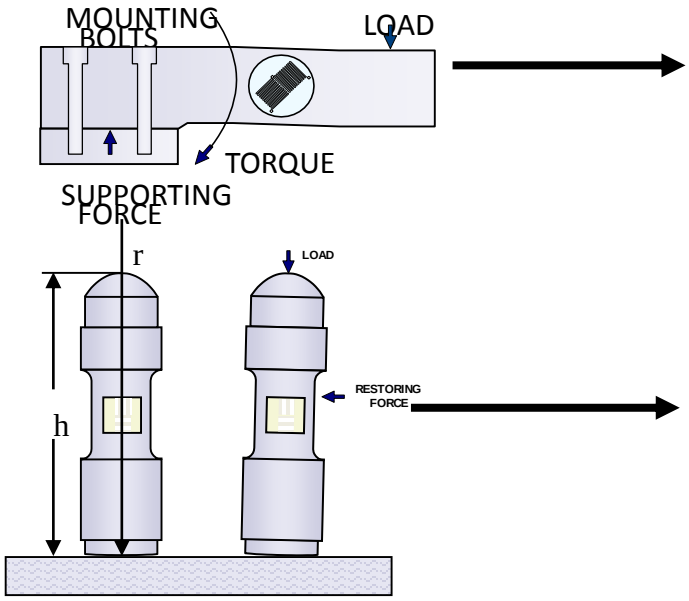




System Components

Why Sartorius –Intec compression cells outperform the competition

- **Pure Mechanical Fundamental Physics**
  - Only our unique rocker pin design separates, mechanically, horizontal from vertical forces. A PR 6201 cannot (by design) take side forces. A beam cell can (and does)



Design

- Each cell must be made perfectly:
  - Identical perfect alloy
  - Perfect gage manufacture
  - Gage attachment perfect and consistent
  - Low signal output reduces creep and drift (3mV/V vs 1mV/V)
  - Less compression (3mm vs 0.5mm)
  - Temperature compensation over entire range of output and operating ranges
  - Exact mV/V output for each cell from the first cell manufactured till now

Benefits

- All cells can be replaced without recalibration
- Output never changes with side-load, motion, time, or temperature
- Impervious to water
- Calibration is accurate without spanning a mass
- Incredible intrinsic resolution and accuracy

Requirements

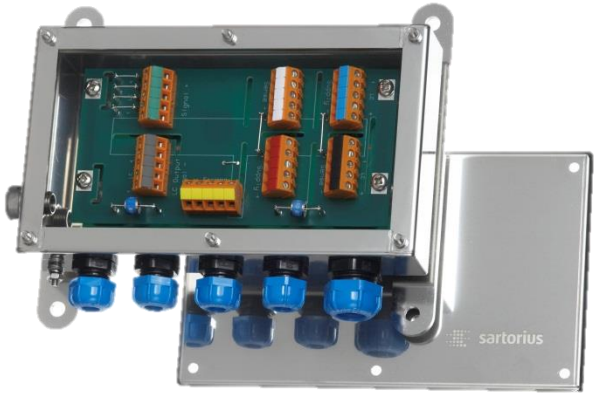
- Must be able to amplify the low current signal from a load cell and be linear and drift free.
- Must have an A/D capable of very high precision.
- Must be able to communicate with process controls or must be an industry standard process controller (IEC61131-3)

Resolution

- Most instruments are designed to be Legal for Trade (5,000 to 10,000 divisions from a 3mV/V signal.
- At 10V excitation, a 5,000 division sensitivity would be 6uV/div – which is a typical response for an inexpensive instrument. Many instruments can resolve 0.5uV/div
- The highest resolution for a analog strain gage is 7.5 Million divisions from an 8V source. (0.003uV/div)

Load cells are in groups of 3 to 6 and constitute a single analog scale

- With perfectly matched load cells, trim pots are not needed so a junction box needs to be provided to sum the signals for the instrumentation
- The box must be resistant to signal changes caused by moisture and also be highly resistant to moisture.
- Load cell cable needs to be capable of transmitting extremely weak signals without distortion caused by inductive or capacitive reactance
- Load cell and “home run” cable must be impervious to water ingression as well as resistant to UV, cracking or stretching.
- We recommend a PTFE coating with a Kevlar center and separate shielding on the signal wires as well as triple shielding overall



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Mounting Kits with Integrated Safety

Designed for use in process vessel and silo weighing. They are matched to the load cells and can easily be installed.

High accuracy and safety

Made of mild or stainless steel

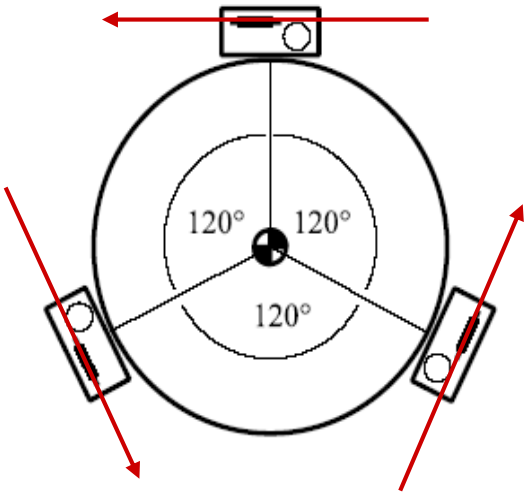
Capacity range from 500 kg to 300 t

designed for horizontal forces from 25kN to 200kN

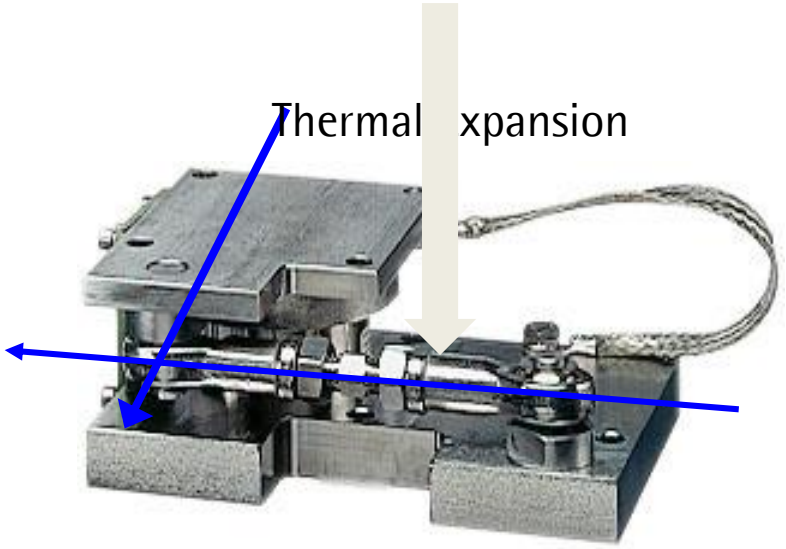
designed for vertical forces from 30kN to 250kN

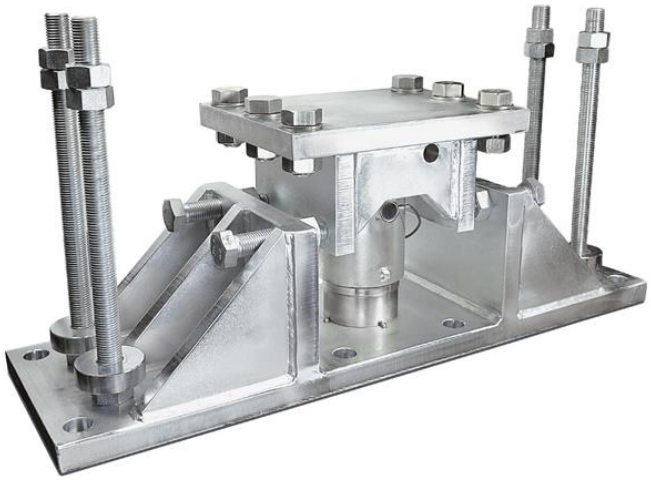
Constraining and Proper Load Cell Mounting

- Our unique mounting solution eliminates side-force influences while allowing for thermal expansion of the vessel.
- Load cells can be easily exchanged: Only ½ inch lift of vessel is required



Force Protection!

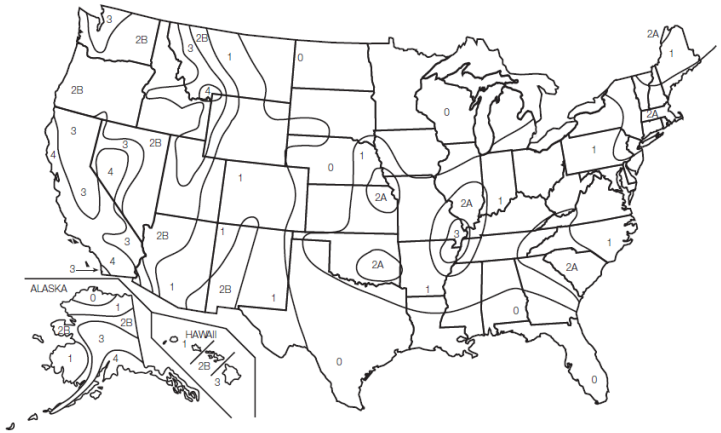


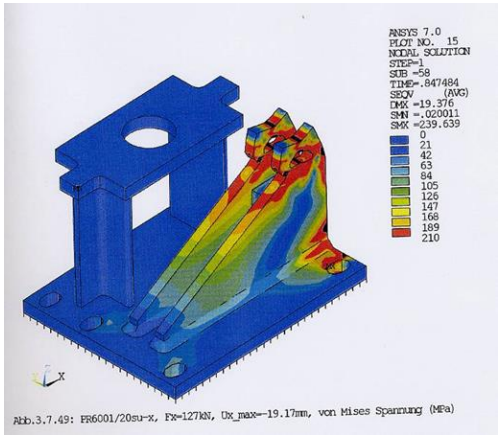


Seismic Mount

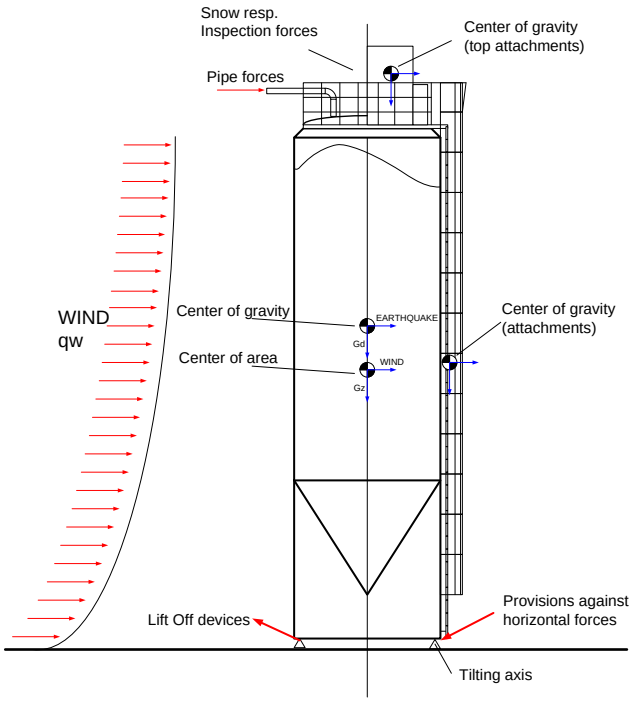
Designed for highest forces and loads occuring in seismic areas and strong wind loads on heavy silos

- made of chromated steel
- for load cells from 50t to 520t capacity
- designed for horizontal forces from 370kN to 520kN
- permissible lift off forces from 400kN up to 880kN





Selection of the mounting kit



- all load cell types offer an individual range of mounting kits. The kits vary in their capacity of force compensation
- for inside installations without an earthquake risk usually mounting kits with lower force levels can be accepted
- for outside installations wind and earthquake effects stronger mounting kits need to be selected
- the forces always have to be calculated by the vessel or silo manufacturer
- a wind and earthquake calculation tool can support in the selection of mounting kits

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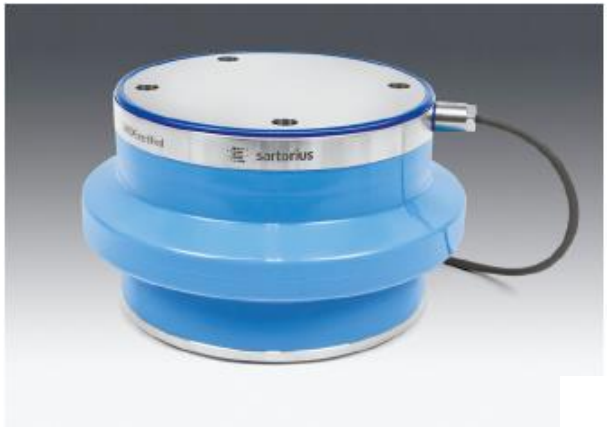
- Optimised surface finish
- Smooth and clean shape
- Self draining design
- Avoiding of gaps
- EHEDG approved

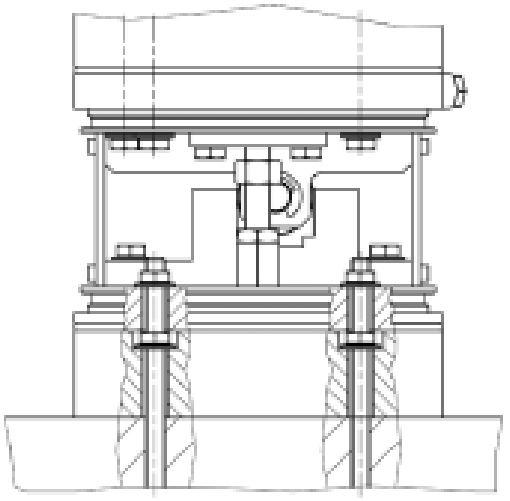
EHEDG EUROPEAN HYGIENIC ENGINEERING & DESIGN GROUP

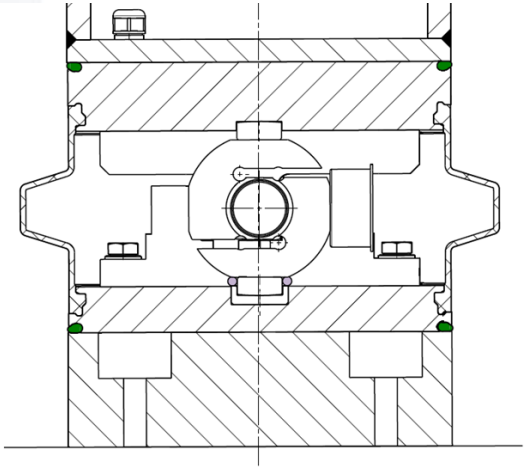
ASSESSMENT

Verification of the cleanability
of load cell PR6202
as per EHEDG recommendations
Report No 105.2/05.11.2005

Specialty Load Cells







Hygienic designs IP69k Silicone rubber surrounding sealed mount. Same serviceability as other mounts inside.

Instrumentation

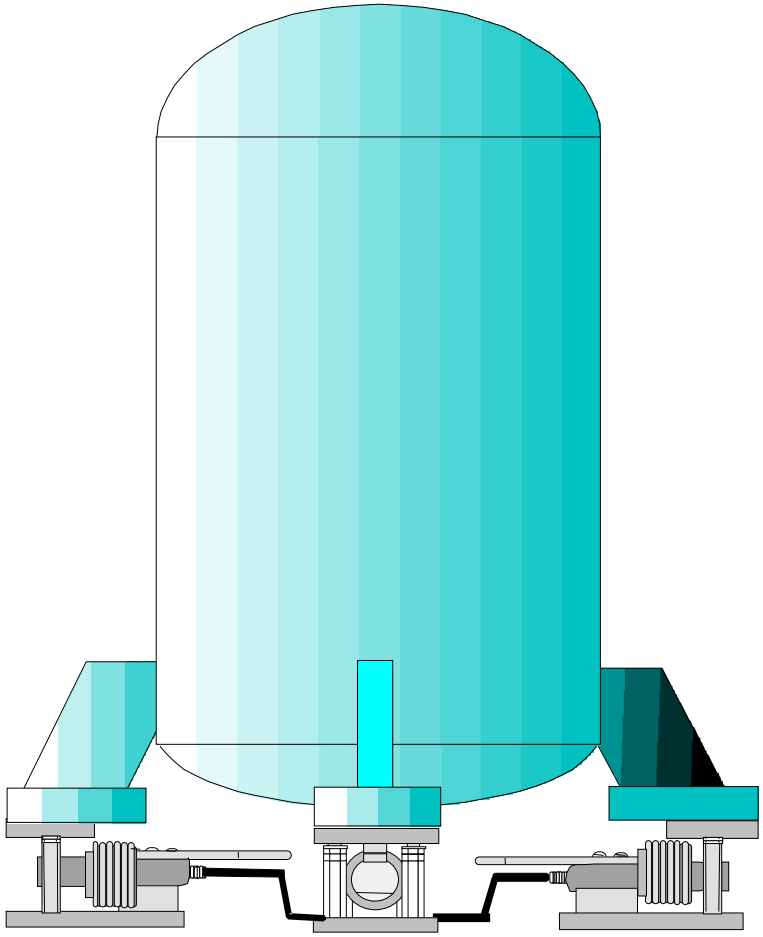
- Must be able to amplify the low current signal from a load cell and be linear and drift free

Transmitters

Indicators

Controllers

- Design Considerations – Tank and Silo Weighing



What is a tank scale?

Process Vessel or Tank

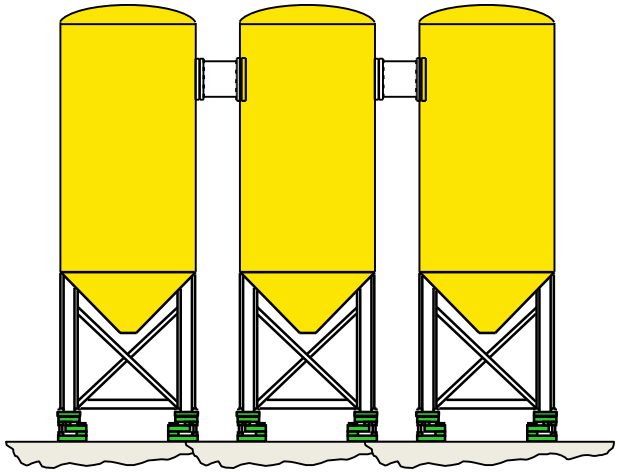
+

Load Cell Transducers
(Weighing Modules)

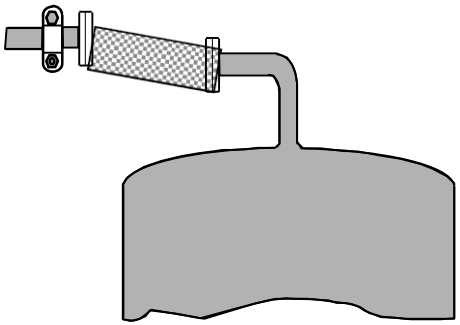
= A Tank Scale

Piping Considerations

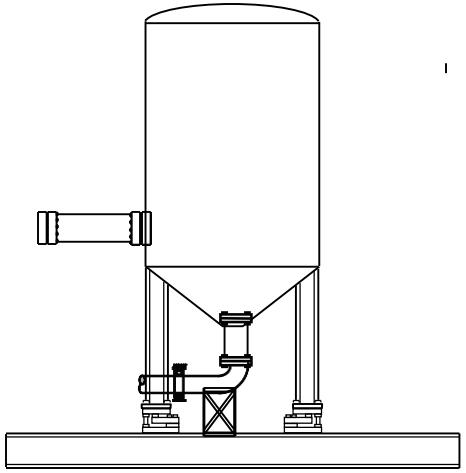
Rigid tank to tank connections



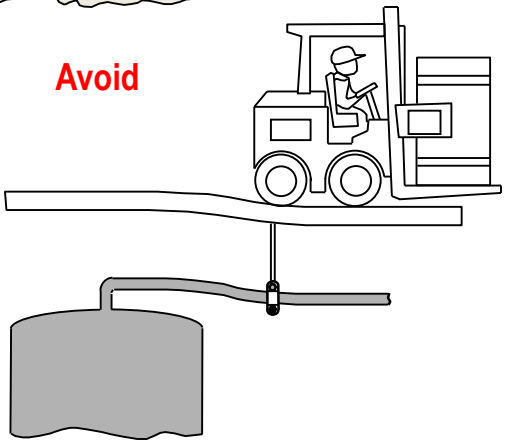
Improperly installed flexable connections



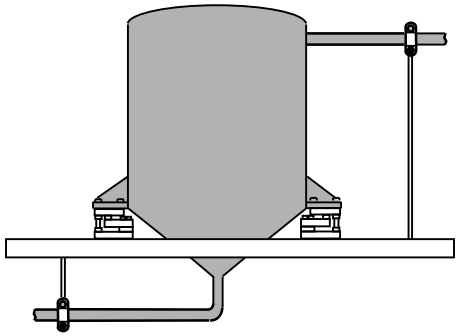
Rigid pipe connections



Avoid



Correct



What are we going to cover?

- System Performance, what can I expect?
  - Accuracy –vs- Resolution
- the components matter?
  - How do they affect system performance?
- What factors affect my accuracy?
  - Environmental, structural, design, etc….
- How do I determine the number of weigh modules I need for my system?
  - What capacity should they be?
- What other provisions should I put in my weigh vessel?

System Performance

How accurate can my scaled tank be?

The system is theoretically capable of the same accuracy as the weighing equipment used.

<u>Things to ponder when considering accuracy:</u>

Piping

Structural supports

Vessel Interaction

Mixers

Low Resolution Instrumentation

System Performance

Accuracy: the degree of closeness of measurements of a quantity to that quantity's actual true value, or more simply the value indicated on the devices display as compared to a known standard.

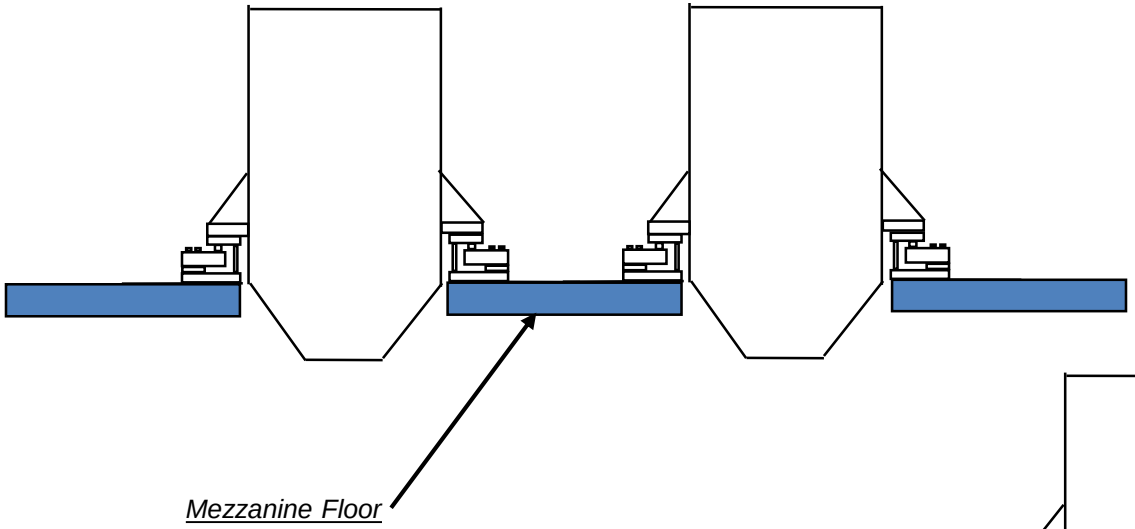
Repeatability: the devices ability to consistently display the same weight each time it is applied.

Resolution/Readability: Smallest difference that can still be read on a display.

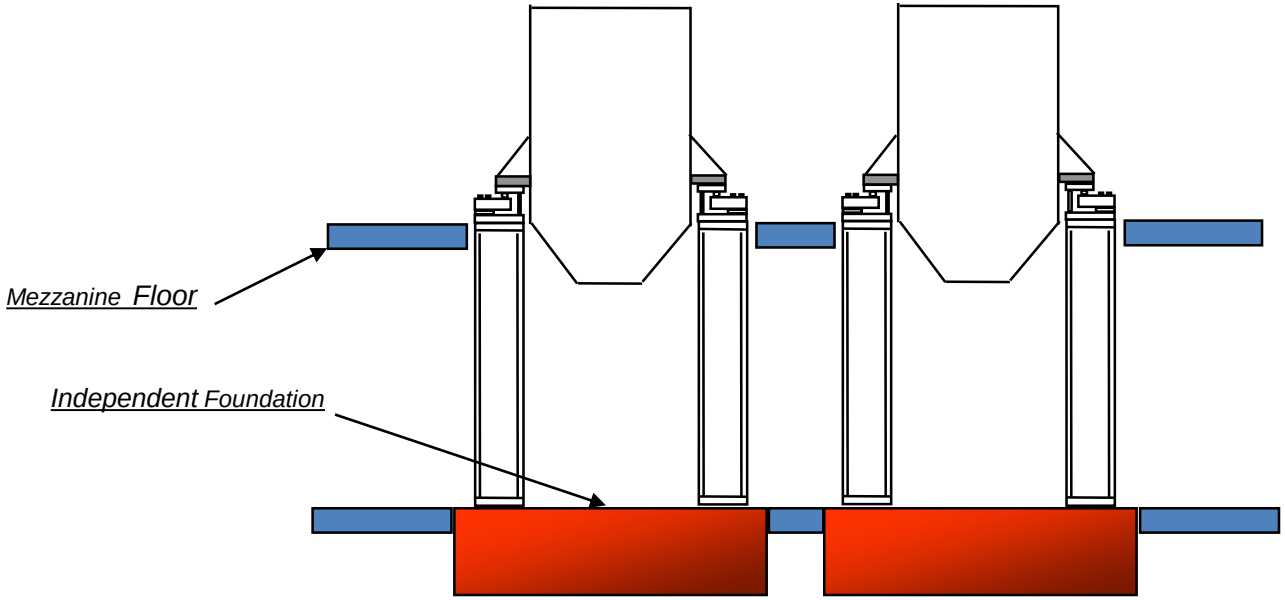
I can have a 5000kg tank scale that reads by .05 kg, however it is unlikely that I will ever see that accuracy in the real world!

Structural Support

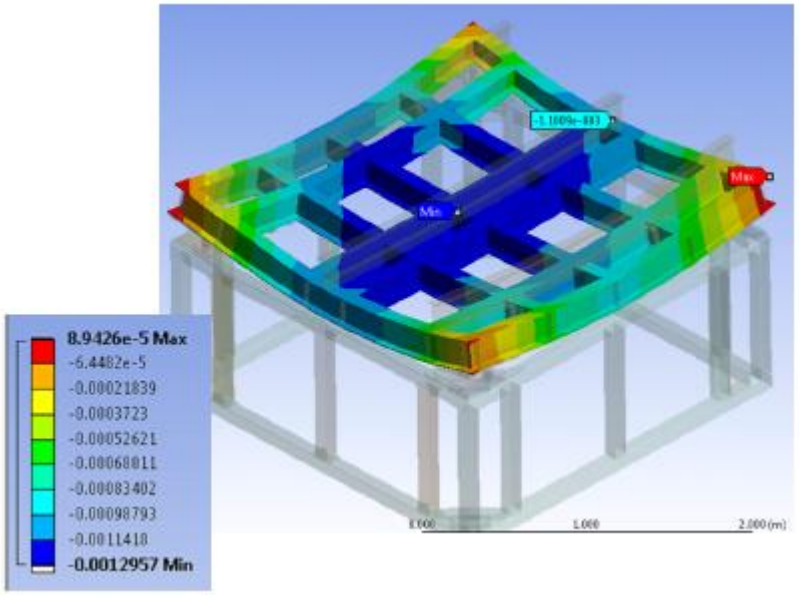
Not So Good



Fantastic



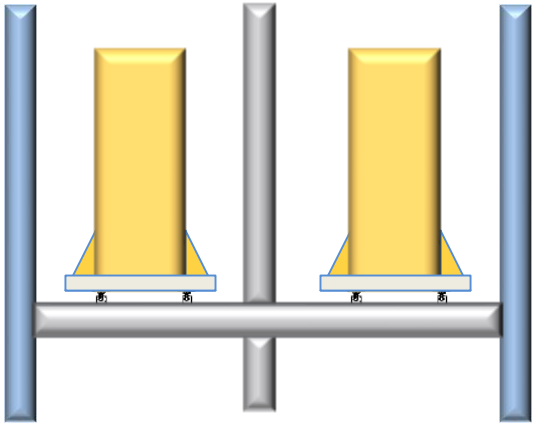
Vessels on steel structures



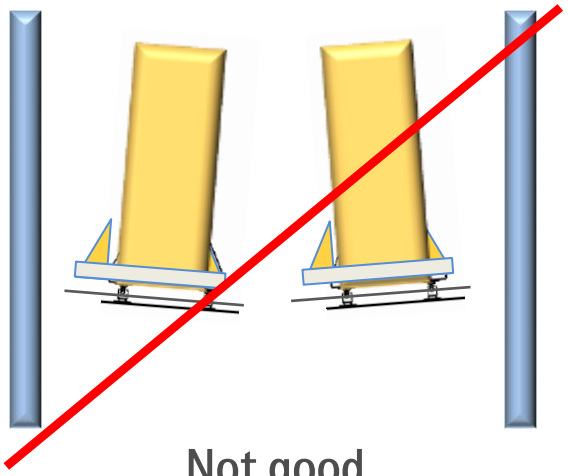
- deflection can lead to tilting of load cells
- heavy tilting has an impact on accuracy
- 1mm deflection per 1.000 mm is ideal
- deflection must be equal

Standing vessels on beams

Provide a rigid foundation that does not deflect under load



good



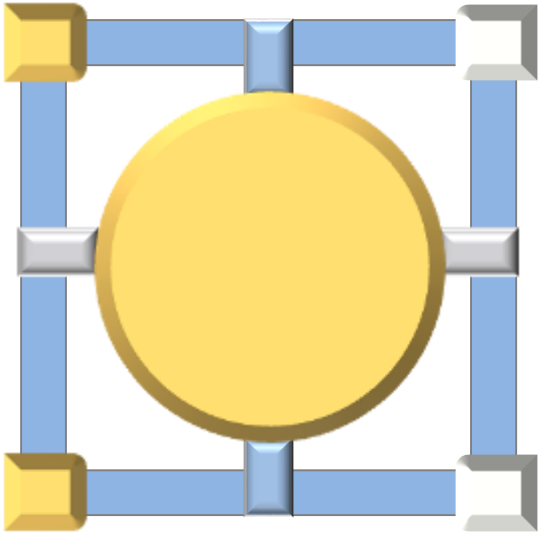
Not good

Every vessel needs to stand on an independent structure to avoid that

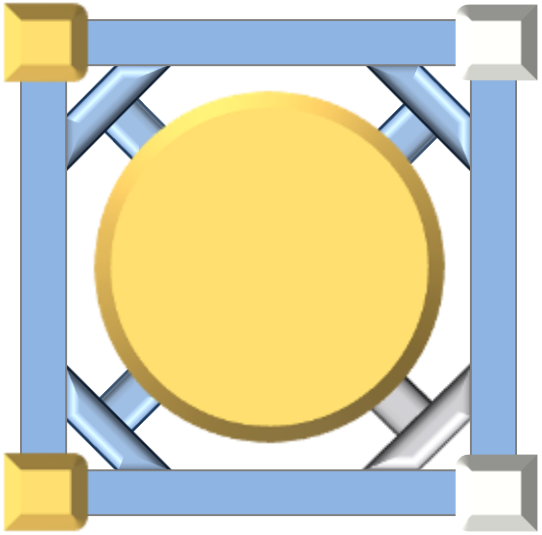
the measuring result in 1 tank is influenced by the level inside the other tank

Design of support frames

Weighing frames



good

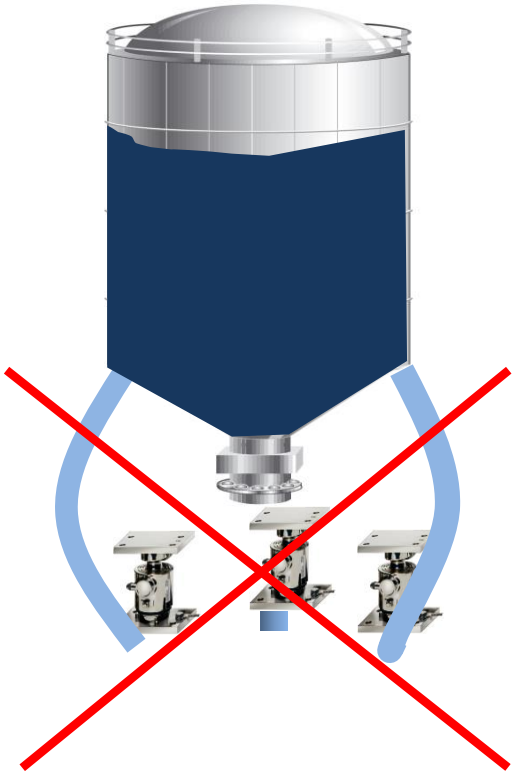


better

How many legs are ideal?

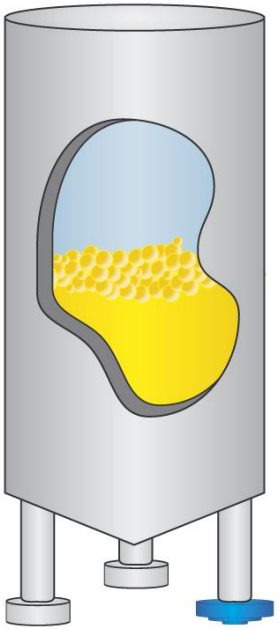
- 3 legs are ideal as the vessel always has full contact with the ground
- Use of more than 3 load cells results in a statically undefined system, one leg might not be in contact with the ground
- Installations with 4 load points or more are used very widely however
- The more load points there are the more time for levelling must be provided

Design of the vessel body



- Ensure stiffness of legs under load

The basics of level control



- Vessel with 3 legs and one load sensor
- Vessel is calibrated with signal of one sensor only
- System accuracy 1-2%
- Insensitive to density variations
- Sensitive to strong side forces

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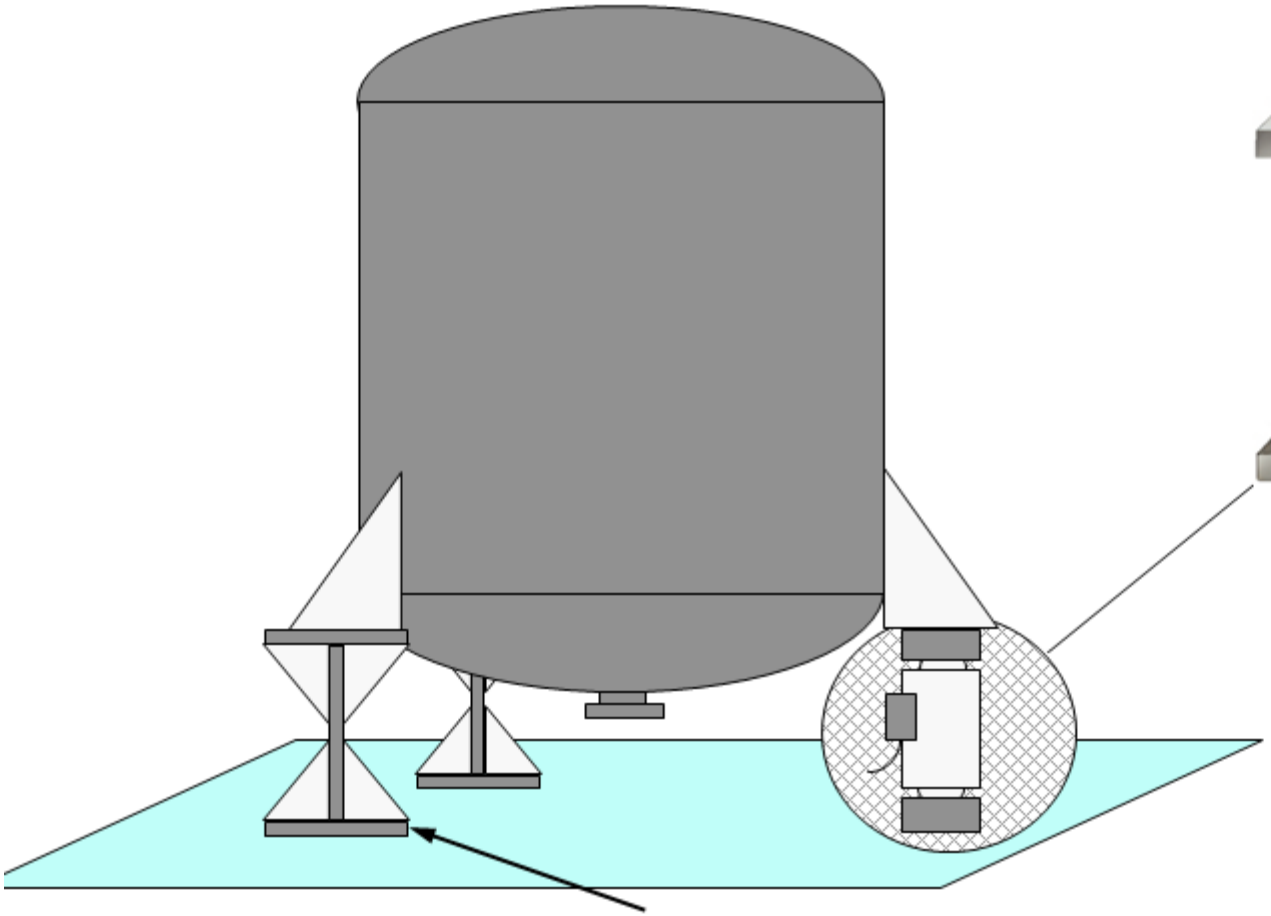
Pivot weighing for higher side forces

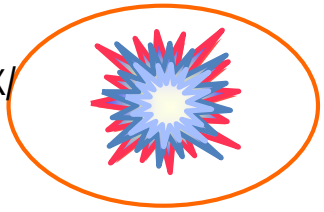


e.g. PR 6201

Standing hopper with two **pivots** for best sensitivity of the load cell, mounting kit can be constrained

External influences

Equipment must be suitable to the ATEX/ FM classification



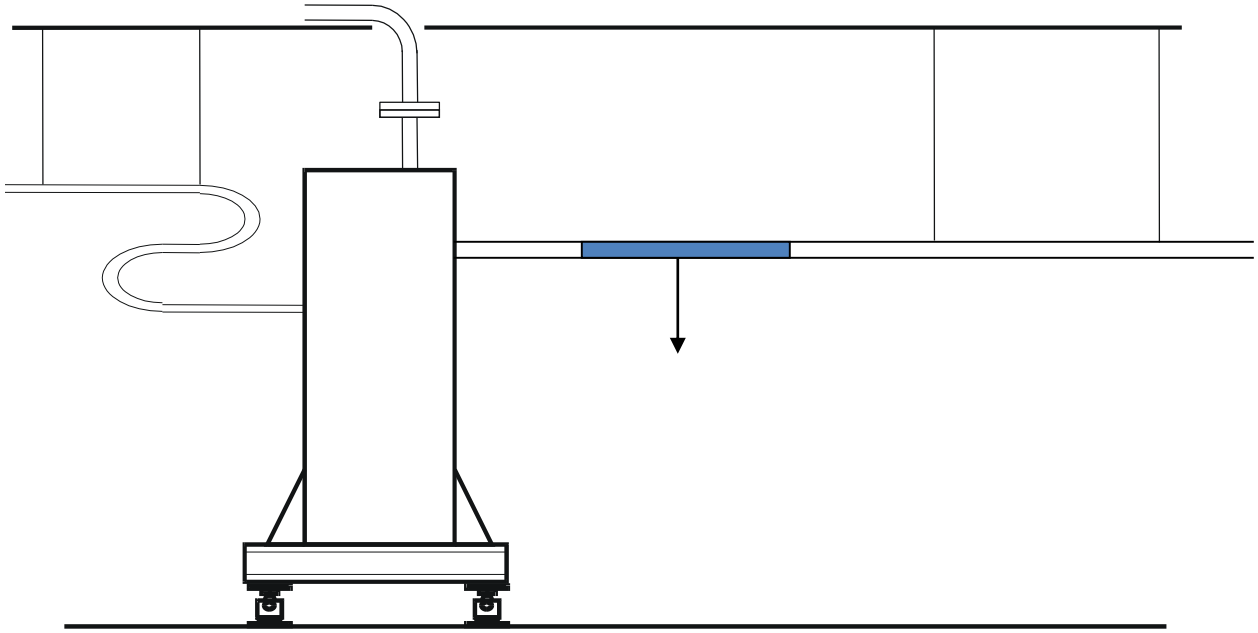
Accessories such as mixers need to be part of the total weighing system, not separate

Pipes need to enter from the side and should use flexible connections

Load cells and mounting solutions need to take side forces into consideration for protection

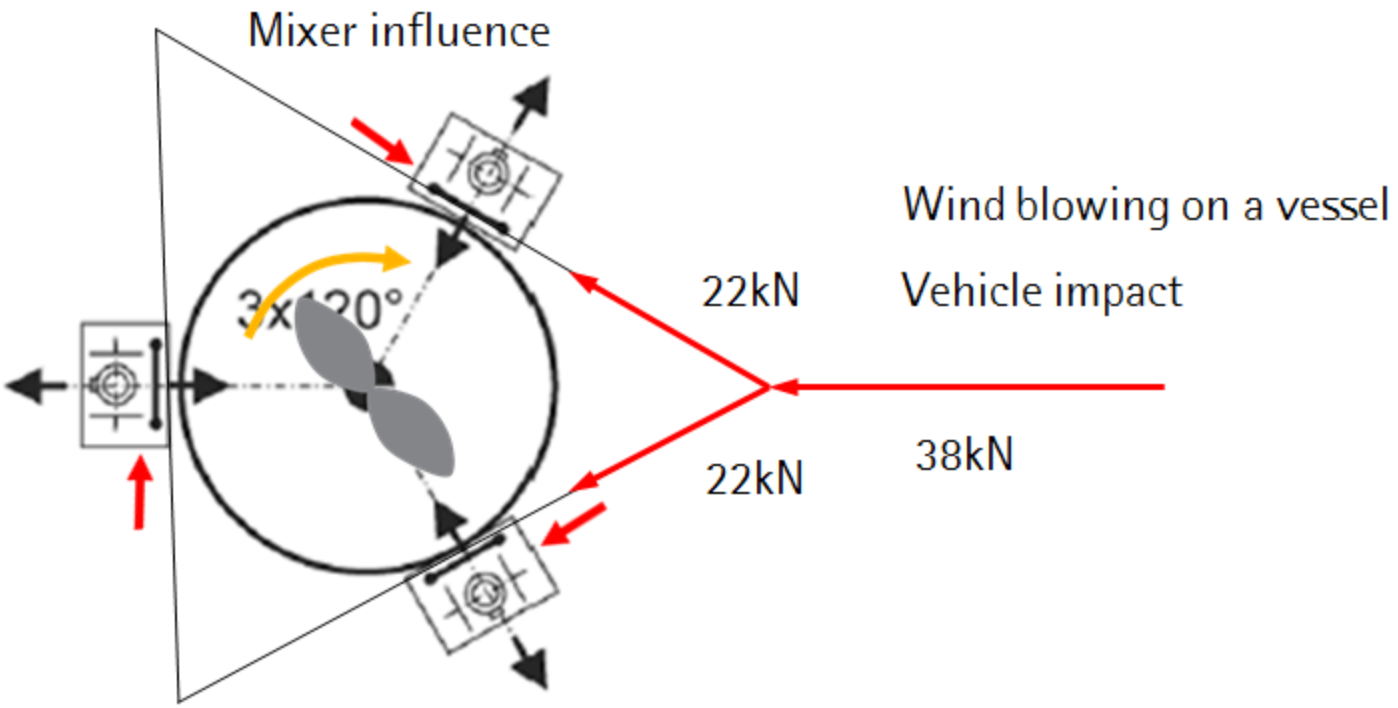
Constrainers need to be utilized to properly mount and position the load cell in addition to providing protection from side forces

Pipes and Connections

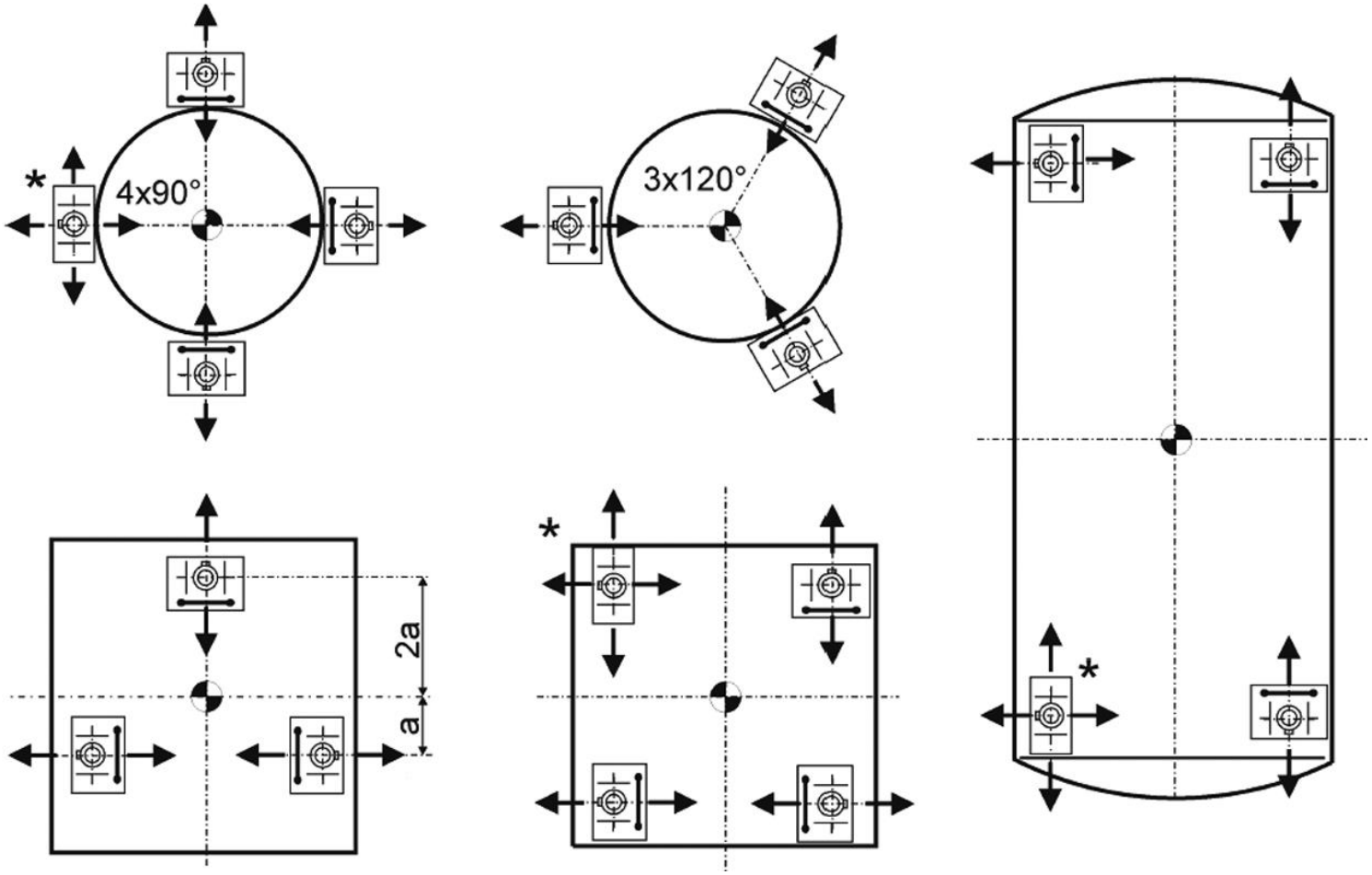


- Stiff pipes can have an influence to the weighing result
- Liquids in big pipes can have an influence on the weight of the vessel

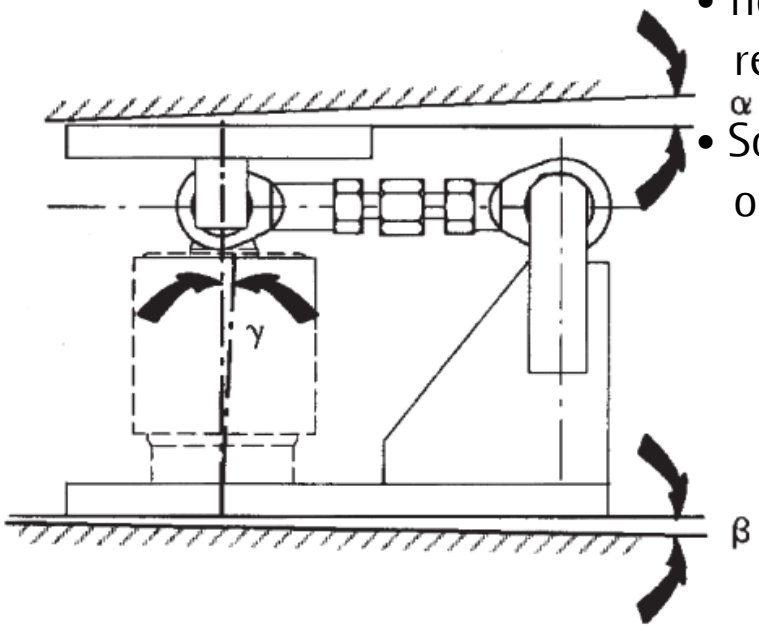
Constraining – introduction of forces



Constraining of Tanks and Hoppers



Condition of the floor



- floor must be even, small slopes will affect the result
- Solid floor structure allowing to insert anchor bolts or to weld the mounting kit plate

To achieve the specifications, the angle should not exceed

$\alpha = 2°$

$\beta = 0.5°$

$\gamma = 1°$

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