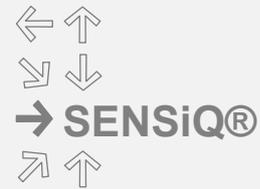


Hopper Scales with SENSiQ®

Engineering and design rules

- Defining hopper scales
- Dimensioning hopper scales
- Selecting load cell mounts
- Ambient influences and shunt forces
- Hopper scale accuracy



Rules to ensure proper operation and high accuracy

1) Defining hopper scales



Net weight acquisition systems mounted on load cells and load application elements, e.g. tanks, silos, reactors, mixers, agitator hoppers.

The more closely these rules are observed, the lower the local influences on operation and accuracy.

The choice of the right mechanical components for the particular application, proper installation and consideration of environmental conditions, e.g. piping connectors, wind loads and process sequence, are of particular importance to accuracy.

Our installation and commissioning instructions as well as the relevant spec sheets detail use, configuration and functions. If hoppers are subjected to shunt forces from existing piping connections, pay particular attention to the rules stated under Item 4.

Proper scale dimensioning requires the following details:

- Weighing range
- Required resolution
- Required accuracy (legal-for-trade?)
- Number of load points (load cells)
- Dead load (hopper's own weight)
- Asymmetric load
- Dynamic loads
- Wind loads

2) Dimensioning hopper scales

The load cell rated capacity needed is calculated using the following formula:

$$\text{L/C rated capacity} = \frac{(\text{weighing range} + \text{tare load}) * \text{safety factor}}{\text{number of support points}}$$

To acquire load cell output signal/digit (Ua/d):

$$Ua/d = \frac{\text{weighing range} * \text{sensitivity} * \text{supply voltage} * 1000}{\text{number of L/Cs} * \text{load cell rated capacity} * \text{resolution}}$$



With 3 load points, factor in at least 25 % for safety.
With 4 support points, as a rule of thumb, use 3 load points. In worst case scenario, if the construction is very rigid, the load can even act on just 2 support points.

Select the next largest available load cell rated capacity and relevant quality using the relevant spec sheet.

With legal-for-trade scales, ensure minimum load cell utilization in accordance with spec sheet.

Minimum utilization = weighing range: total of load cells rated capacities (with SENSiQ® RT load cells at least 15 %).

With non-legal-for-trade scales, depending on duty and application, 5 % load cell utilization will suffice.

Observe minimum input signal of evaluation electronics provided.

Example:

| | | |
|---------------------------|-----------------------|------------------------|
| Weighing range: | 15 t | Result: 4,275 µV/d |
| Sensitivity: | 2.85 mV/V | |
| Supply voltage: | 12 V | |
| Number of load cells: | 4 | |
| Load cell rated capacity: | 10 t (SENSiQ® RTN C3) | |
| Resolution: | 3000 digits | (5 kg increment value) |

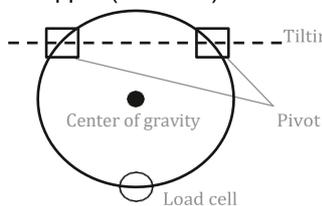
When using pivots (partial load measurement), first determine the load on every weighing support point.

Then establish load cell output signal as described above.

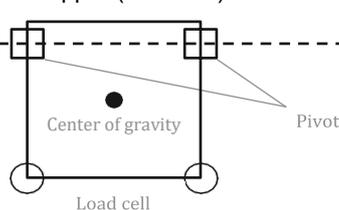
The achievable accuracy depends on the material used (solids, liquids; see Item 3, SENSiQ® fixed mounts (SFM)).

Three load distribution examples:

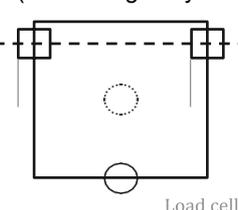
A) Round hopper (each 1/3)



B) Square hopper (each 1/4)



C) Square hopper (center of gravity undefined)



3) Selecting Load Cell Mount

Select load cell mounts depending on application and accuracy requirements.

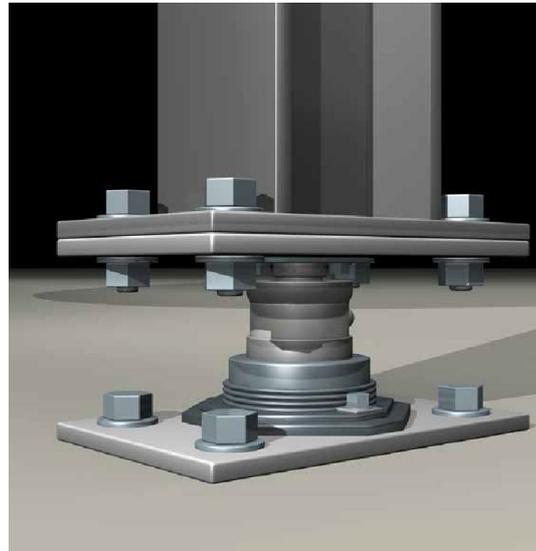
SENSiQ® Elastomer Mount (SEM)

Typical applications: hopper scales, roller table scales, crane scales and road weighbridges.

Self-centering and resistant to lateral forces. Insensitive to max. $0.6^\circ = 10 \text{ mm/m}$ inclination of support structure. Service-friendly and maintenance-free. Observe lateral stiffness of elastomer (differs depending on rated capacity) (the admissible lateral force on load cells must not be exceeded at nominal hopper deflection).

Limit stops and lift-off protection have to be provided by user.

More information can be found in spec sheet BVD2044.

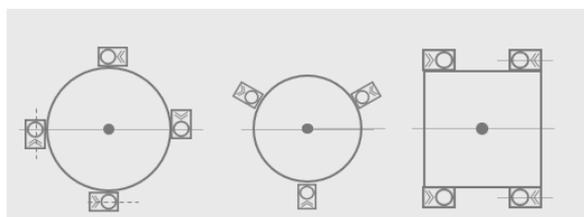
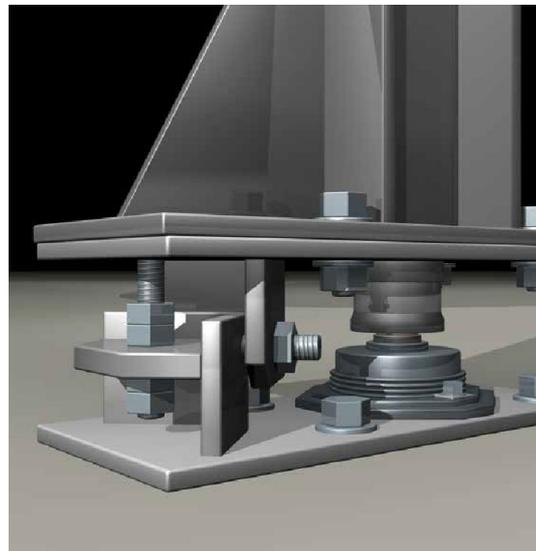


SENSiQ® Secure Mount (SSM)

Typical applications: hopper, silo, tank, and mixer scales. Extended SENSiQ® elastomer mount complete with head and foot plates, integrated limit stops and lift-off protection. Up to and including rated capacity of 33 t, the maximum horizontal force is 10 % of the rated capacity of the mount and maximum vertical lift-off force is 15 % of rated capacity of the mount. With a rated capacity of 47 t or higher, the maximum horizontal force and vertical force preventing lift-off is 20 % of the rated capacity of the mount. For applications with higher horizontal and lift-off loads, use the SENSiQ® Secure mount PLUS with a maximum horizontal and lift-off capacity of 40 % of the rated capacity of the mount for rated capacities of between 10 t and 330 t.

If the loads on limit stops and lift-off protection are even higher, take additional actions (e.g. fit external bumpers and external lift-off protection). Strictly observe specified arrangement (see sketch).

More information can be found in spec sheets BVD2083, BVD2443 and BVD2444



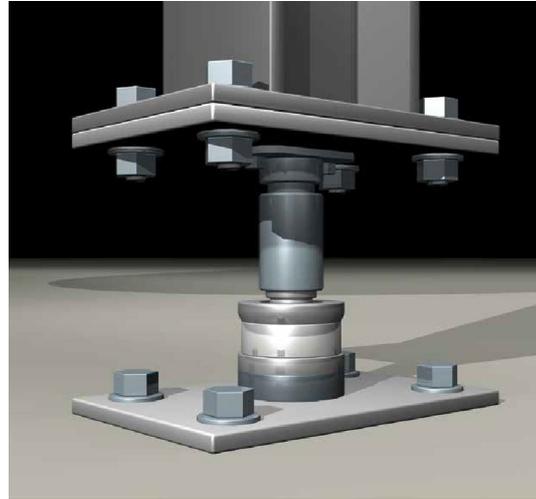
SENSiQ® Pendulum Mount (SPM)

Typical applications: hopper and vehicle scales.
 Designed for extremely rugged environments. Suitable for maximum measuring accuracy. Self-centering, maximum admissible inclination of existing connecting surface $0.6^\circ = 10 \text{ mm/m}$.

Smaller spring deflection compared with SENSiQ® SEM/SSM as there is no elastomer mount.

Pendulum limit stops and lift-off protection have to be provided by user.

More information can be found in spec sheet BVD2025



SENSiQ® Fixed Mount (SFM)

Typical applications: for simple weighing tasks on hopper scales with $\geq 5 \text{ t}$ weighing range, e.g. level measuring systems, equipped with one or two load cells (partial measurement). Simple, rugged, flat design, resistant to lateral forces. Sufficient accuracy with defined center of gravity, e.g. for liquid hoppers. Dimensions compatible with SENSiQ® secure or elastomer Mounts.

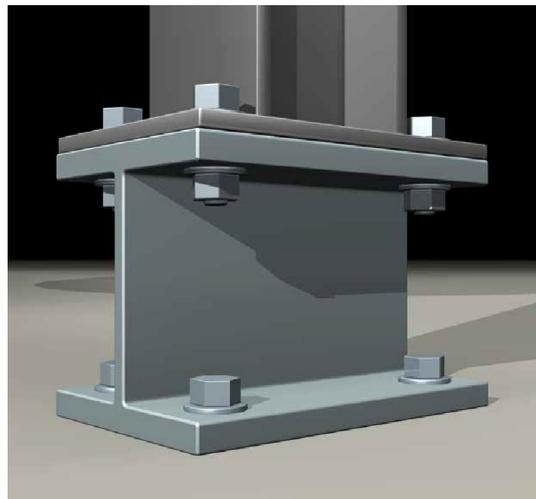
Installation on common tilting line. Typical accuracies (in relation to full scale value) without influence of the immediate environment:

$\geq \pm 0.5 \%$ with liquids

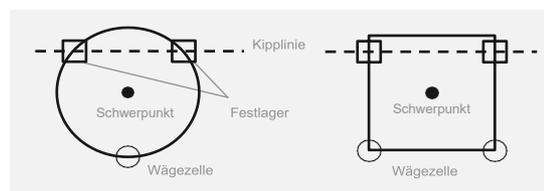
$\geq \pm 1 \%$ with solids

Maximum lateral force in any horizontal direction may be 10 % of the rated capacity of the mount. For higher lateral forces, the SENSiQ® fixed mount PLUS with a maximum admissible lateral force of 40 % of the rated capacity of the mount is available for rated capacities of between 10 t and 220 t.

More information can be found in spec sheets BVD2182 and BVD2442.



Load distribution depends on load carrier / hopper symmetry and horizontal forces (wind load, agitator, pipe connections). In contrast to a full load measurement using load cells, these forces may cause considerably greater measuring errors depending on the application point and effective direction.



4) Ambient influences and shunt forces



Appropriate measures during planning and design can minimize, or eliminate, shunt forces

Shunt forces

The load to be determined may only be applied via defined support points. If partial loads bypass the defined support points (shunt forces), measuring errors will result.

Shunt forces may occur if:

- the load receptor makes contact with the permanent construction (foundation, frame, support structure)
- pipes and other connections to the scale (e.g. agitator cable) in direction of load cell load are too rigid
- limit stops are improperly mounted/adjusted or blocked by grime, material residues or corrosion
- compensators are too rigid or grimed (particularly through material residues with bellows-type compensators)

Examples of how to avoid shunt forces



Fig 1

Free flanged inlet connection, if necessary, with labyrinth ring / cover

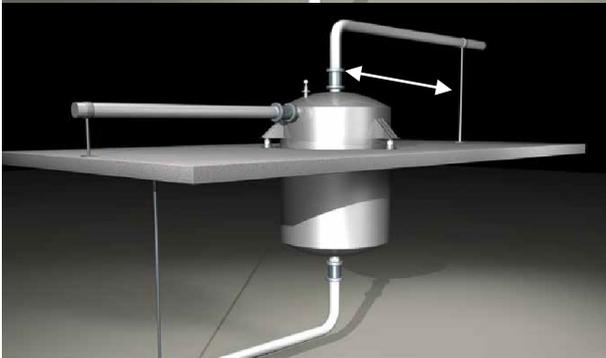


Fig 2

Horizontal supply line sufficiently long to avoid faults resulting from pipe deformation.

Important: Never support supply line near hopper.

Rule of thumb: $L = 30 \times \text{pipe diameter}$



Fig 3

If pressure (or underpressure) is present on hoppers, ensure identical compensator diameter!



Fig 4

Fit compensators or flexible hoses to ensure flexibility of extremely rigid lines with large diameters. Dimension "L" can be halved using a pipe loop (also for Fig. 2).

- Ensure sufficient pipe bend length Design pipe bend horizontally
- Mount support on the side away from the hopper only
- If pipes are very thick, the dual compensators shown considerably reduce shunt forces.

Additional considerations:

Provide venting for cooling/heating jacket. Note level to which hopper heater is filled.

Consider operating state (pressure, temperature, heating).

Reactor and piping pressures cause weighing errors via pipe cross-section.

Remedy: Provide pressure compensation, operate at zero-pressure.

Mount pipes horizontally.

Note heating of pipes through internal medium or radiating heat.

Typical pipe elongation: 0.1 mm/10° C x length.

Irregular warming can cause the pipe to behave like a bimetal thus generating additional bending forces.

Environmental influences through heat, moisture

- Protect load cells from direct insolation and drafts. Remedy: Provide insulating jacket or enclosure.
- Avoid thermal gradients (heat discharge from hopper via load cells).
Remedy: Provide heat insulating plates.
- Protect load cell cable from mechanical damage (rodents) and moisture.
Remedy: Run load cell cable in protective tubes.

Design/installation considerations

- Design platform construction with sufficient stiffness.
- Ensure deflection L/1000
- Run pipes and mount compensators horizontally.
- Compensate vertical lines as gently as possible.
- Provide potential equalization between load cell housing and evaluation electronics.
- Use existing mechanical construction or provide PE line.
- Connect weigh hopper to ground of user construction using flexible connector.
- Design load cell output lines horizontally, plane parallel and sufficiently rigid.
- To avoid mechanical stresses from thermal expansion, always use genuine Schenck Process parts (foot plate and load cells of same material).
- To be able to calibrate and verify your scale, ensure that standard weights of at least 20% of its rated capacity can be applied.
- (This is the prerequisite for legal-for-trade applications).

5) Hopper scale accuracy

The main requirement for attaining the desired scale weighing accuracy is selecting the right load cell rated capacity and quality.

Decisive parameters:

- Characteristic deviation (non-linearity and hysteresis)
- Temperature dependencies of zero signal and characteristic
- Resolution
- Measurement value creep
- Repeatability

With hopper scales, the achievable system accuracy is essentially determined by the ambient influences and process sequence.

Key words:

- Accurate mounting of supports.
- Repeatability influenced by pipes, compensators and other connections.

- Stiffness of mounting platform.
- Agitator vibrations, center of gravity displacement.

With legal-for-trade weighing systems, use load cells of minimum quality C3, and evaluation electronics approved for trade use.

If scale is properly configured in accordance with the instructions provided in these documents, the (legal-for-trade) system accuracy will be comfortably below 0.1%.

With non-legal-for-trade weighing systems, when using SENSiQ™ RT load cells with 0.05% accuracy and proper installation in conjunction with Schenck Process evaluation electronics, 0.1% system accuracy can be achieved.

These accuracies are obtained through input of all scale parameters, i.e. by "theoretical calibration" without application of weights.

Schenck Process will be glad to back you up with:

- Advice
- Engineering
- Design
- Service
- Checks

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