schenck process

Engineering and Design Rules for Hopper Scales

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

we make processes work

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 better these rules are observed, the lower are the local influences on operation and accuracy.

For peak accuracy, the right mechanical components, proper installation and consideration of environmental conditions, e.g. piping connectors, wind loads and process sequence, are of particular importance.

Our installation and commissioning instructions as well as relevant Spec Sheets detail use, configuration and functions. If hoppers are subjected to shunt forces from existing piping, pay heed to the rules given at Item 4.

Proper scale dimensioning requires the following details to be known:

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

2) Dimensioning Hopper Scale

Determine load cell rated capacity using the following formula:

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

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

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

With 3 load points, factor in min. 25% safety. With 4 support points, as a rule of thumb, consider 3. In the worst case, if the construction is very rigid, the load can even act on 2 support points only.

Select appropriate load cell rated capacity and quality using relevant Spec Sheet.

With legal-for-trade scales, ensure minimum load cell utilisation in accordance with Spec Sheet.
Minimum utilisation = weighing range: total of load cells rated capacities (with RT load cells min. 15%).

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

Observe minimum input signal of weighing electronics to be used.

e.g.:	**weighing range:**	**15,000 kg**	**result: 4.275 yV/d**
	sensitivity:	**2.85 mV/V**	
	supply voltage:	**12 V**	
	no. of L/Cs:	**4**	
	load cell rated capacity:	**10 t (RTNC3)**	
	resolution:	**3000 digits (5 kg increment value)**	

When using pivots (partial load measurement), first determine the load in every support point to be weighed. Then acquire load cell output signal as described above.

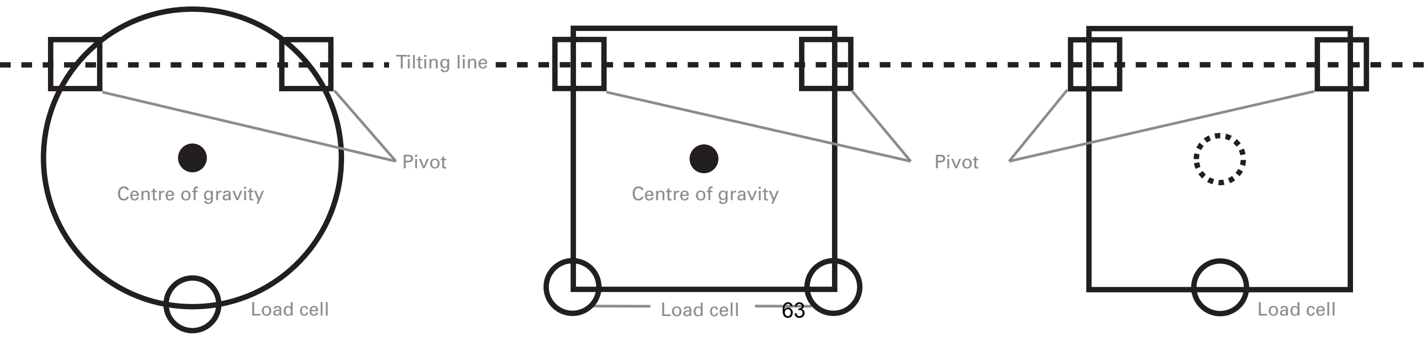
The achievable accuracy depends on material used (solids, liquids; see Item 3, Pivots VFN).

3 load distribution samples

A) Round hopper
(1/3 each)

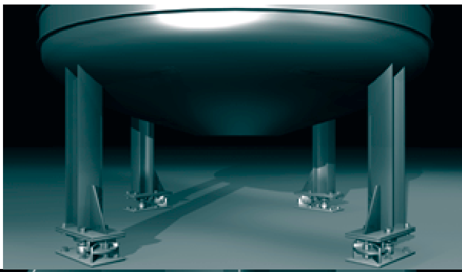
B) Square hopper
(1/4 each)

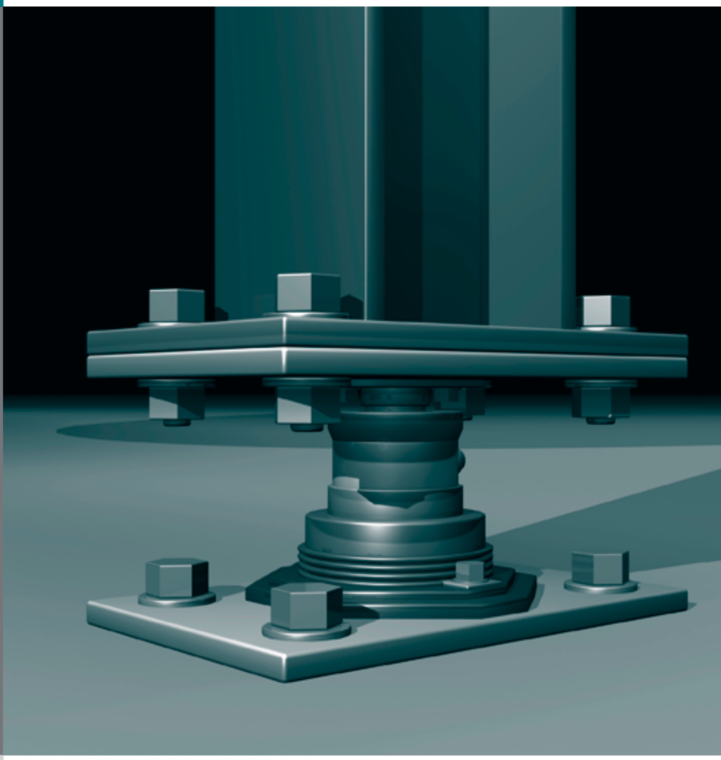
C) Square hopper
(centre of gravity undefined)

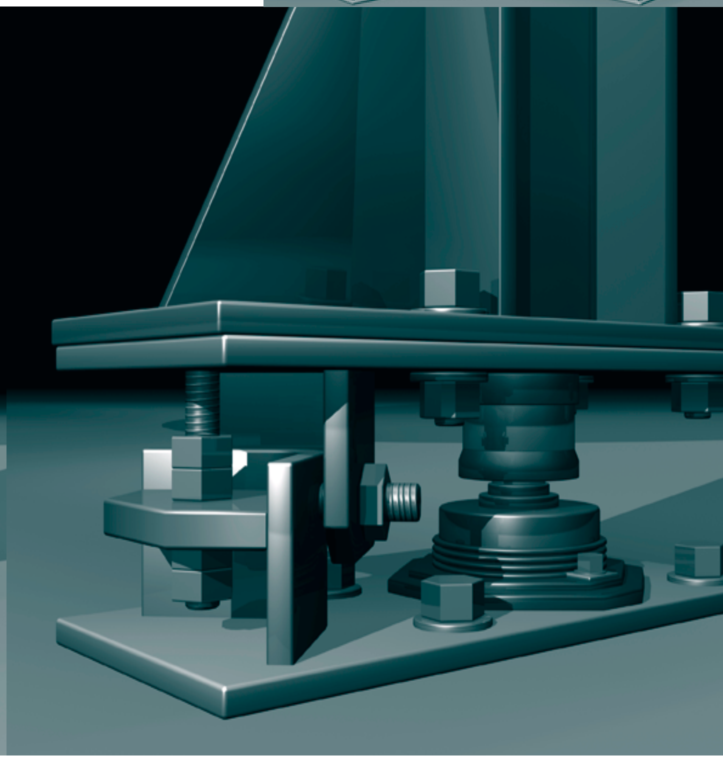


3) Selecting Load Cell Mount

Select load cell mount in accordance with application and accuracy requirements.







Elastomer mount, type VEN

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

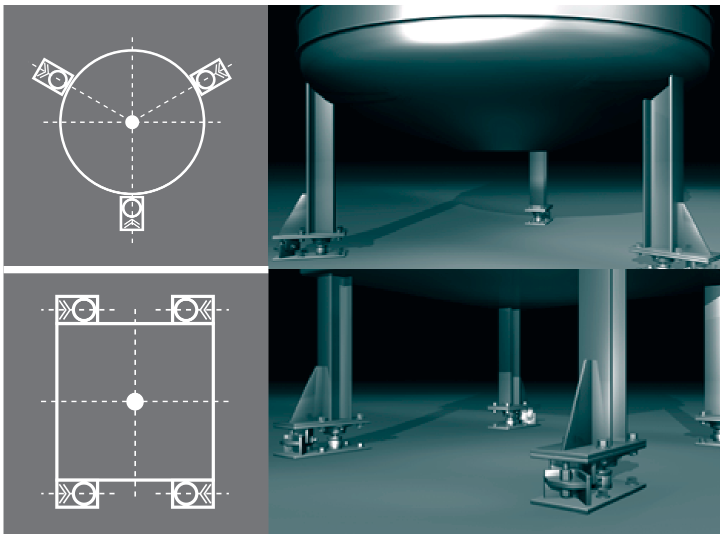
Self-centering and resistant to lateral forces. Insensitive to max. 0.6° = 10 mm/m inclination of support structure. Service-friendly and maintenance-free. Observe lateral stiffness of elastomer (varying as a function of rated capacity) and make sure the admissible lateral force on load cells at nominal hopper deflection is not exceeded.

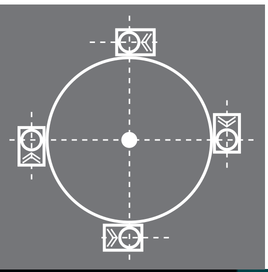
Movement limit stops and hold-downs have to be provided by user.

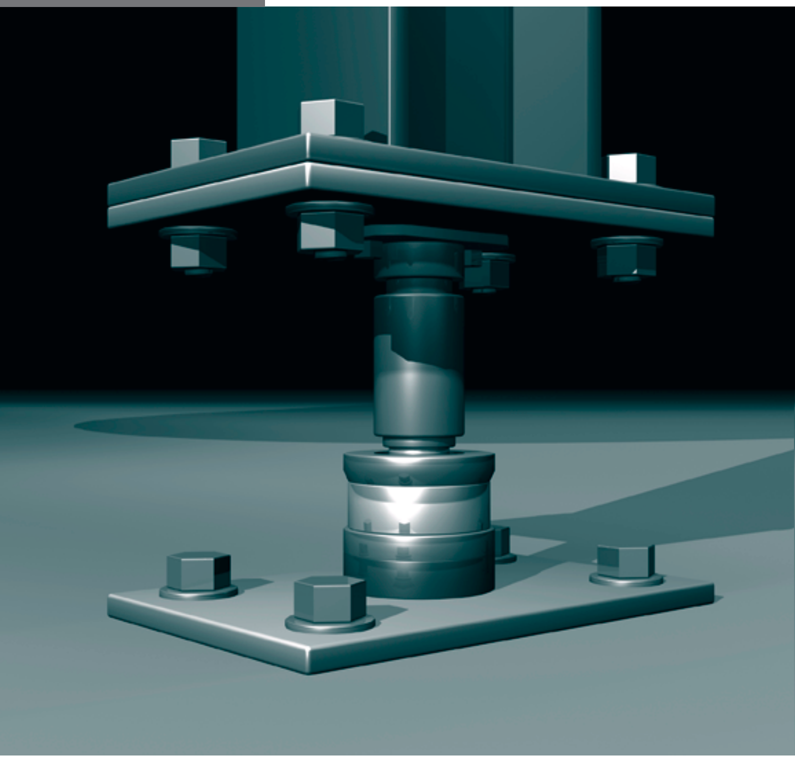
Compact mount, type VKN

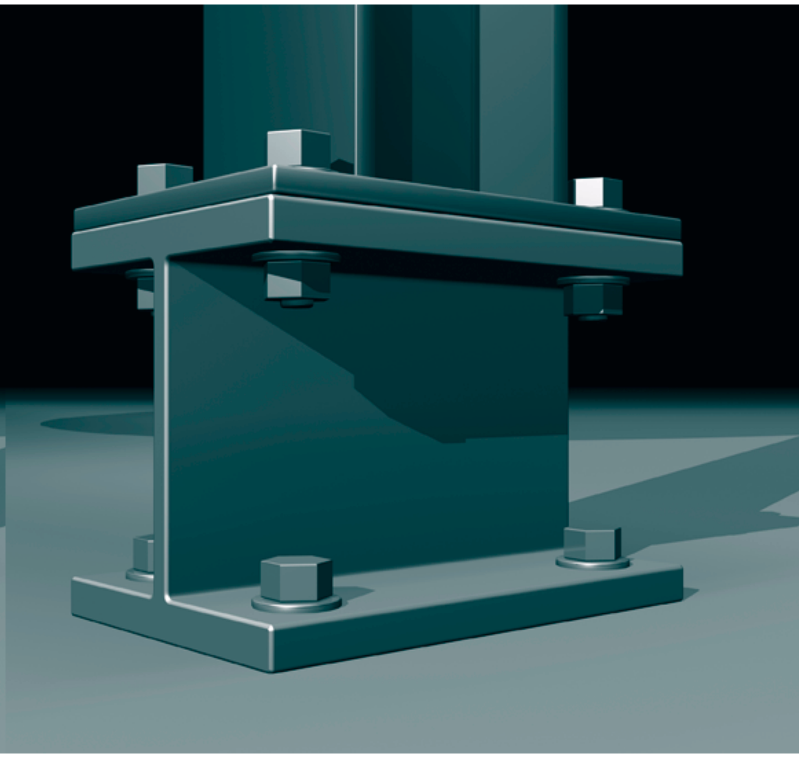
Typical applications: hopper, silo, tank, and mixer scales. VEN mount complete with head and foot plates, integral limit stops and hold-downs. Up to rated capacity VKN 33, maximum horizontal force is 10% * rated capacity of mount; maximum lift-off, 15% of rated capacity of mount. Strictly observe specified arrangement (see sketch).

If load on limit stops and hold-downs is higher than specified in Spec Sheet, provide additional elements (e.g. external bumper checks and hold-downs).









Self-aligning mount, type VPN

Typical applications: hopper and platform scales. Designed for extremely rugged environments. Suitable for highest measuring accuracy. Self-centering. Maximum admissible inclination of existing connecting surface 0.6° = 10 mm/m.

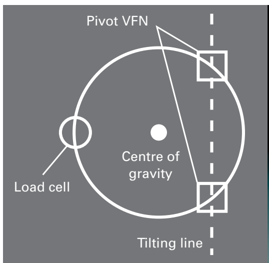
Smaller spring deflection compared to VEN/VKN mounts. Movement limit stops and hold-downs have to be provided by user.

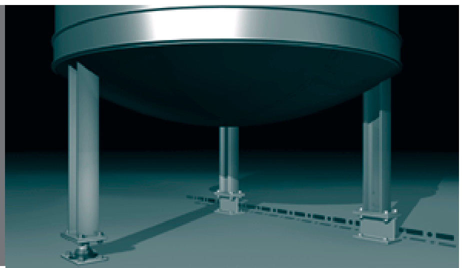
As the local situation may be, movement limits stops and hold-downs should be used.

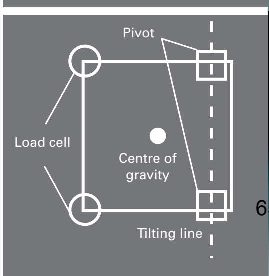
Pivot, type VFN

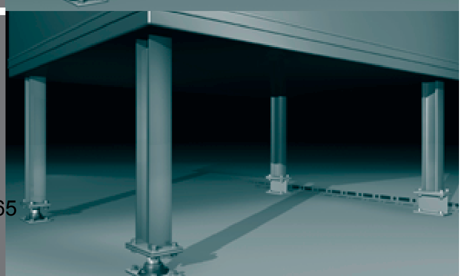
Typical applications: hopper scales with ≧ 5t weighing range for simple weighing tasks, e.g. hopper level measuring systems equipped with one or two load cells (partial measurement). Simple, rugged, flat design, resistant to lateral forces. Sufficient accuracy with defined centre of gravity, e.g. for liquid hoppers. Dimensions compatible with VEN and VKN mounts. Installation on common tilting line. Typical accuracies (related to full scale value) without influence of the immediate environment:

≦ ± 0.5% with liquids
≦ ± 1% with solids



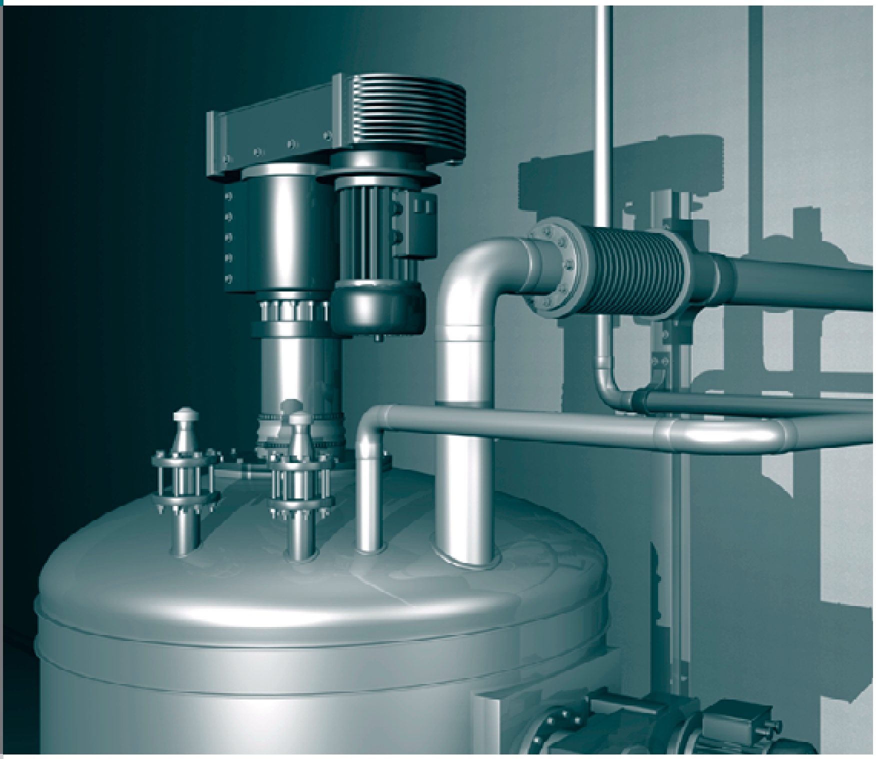






Load distribution depends on load carrier/hopper symmetry and horizontal forces (winds, agitator, pipes). In contrast to full load measurement using load cells, measuring error can be notably higher as a function of application point and effective direction.

4) Ambient Influences and Shunt Forces



Appropriate measures upon planning and design can minimise, or eliminate, shunt forces.

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

Shunt forces possibly occur if:
- load receptor contacts stationary construction (foundation, frame, support structure)
- pipes and other connections to 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)

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 from pipe deformation. Important: never support supply line near hopper.

Rule of thumb: L • 30 x pipe diameter

Always support pipes on scale platform.

Fig. 3
If pressure (or underpressure) is present on hoppers, ensure identical compensator diameter.

Fig. 4
Employ compensators or flexible tubes to ensure flexibility of extremely rigid lines with big diameters. Dimension "L" can be halved using a pipe loop (also for Fig. 2).

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

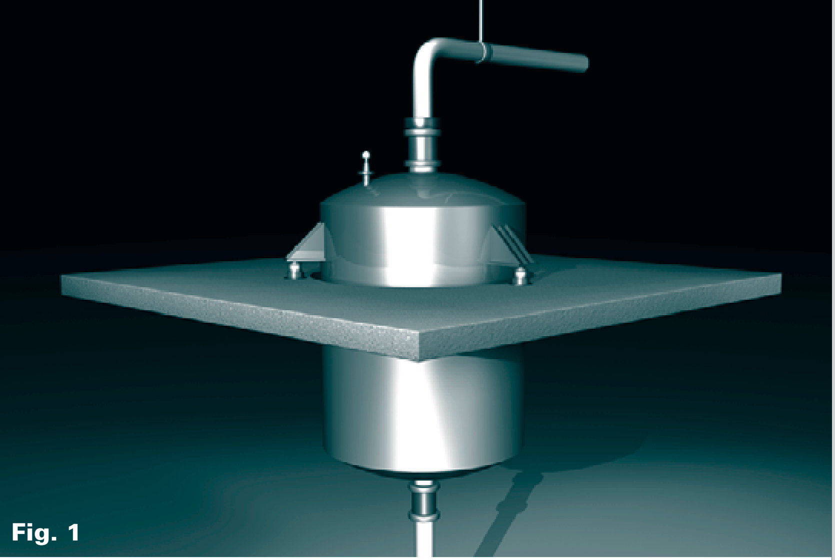


Fig. 1

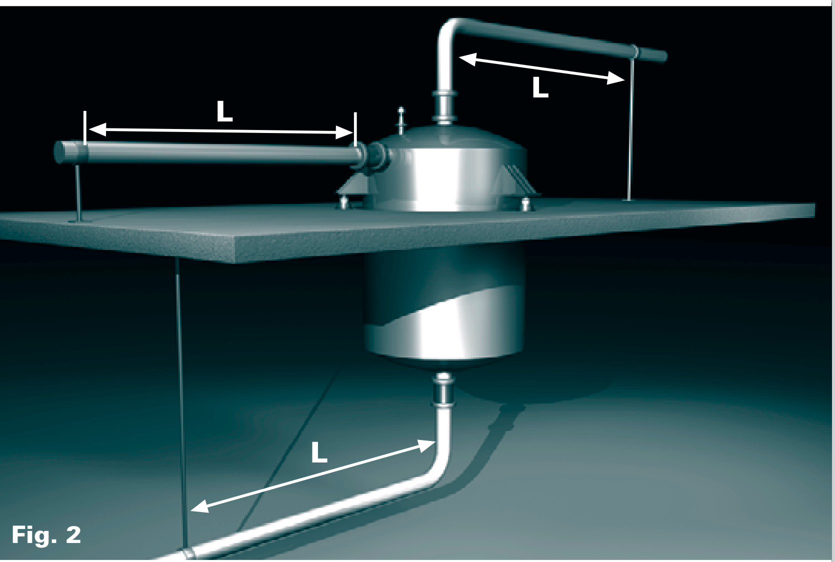


Fig. 2

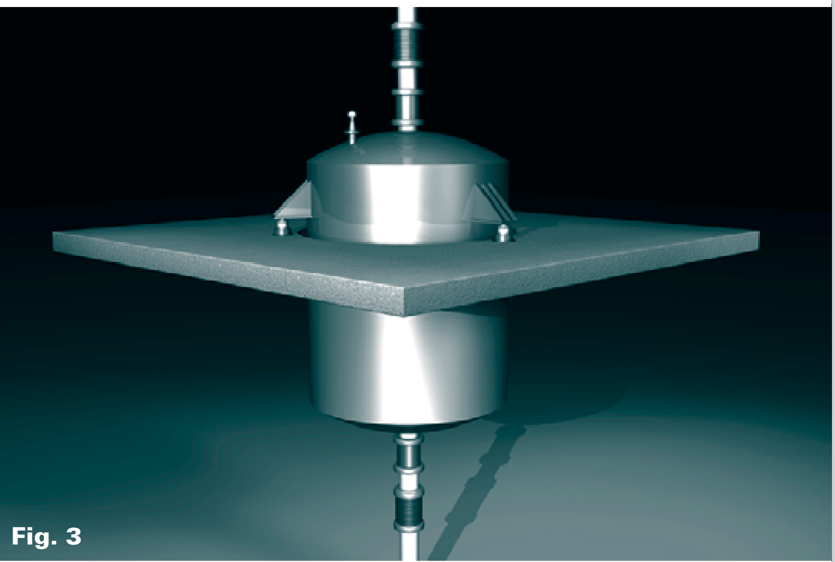


Fig. 3

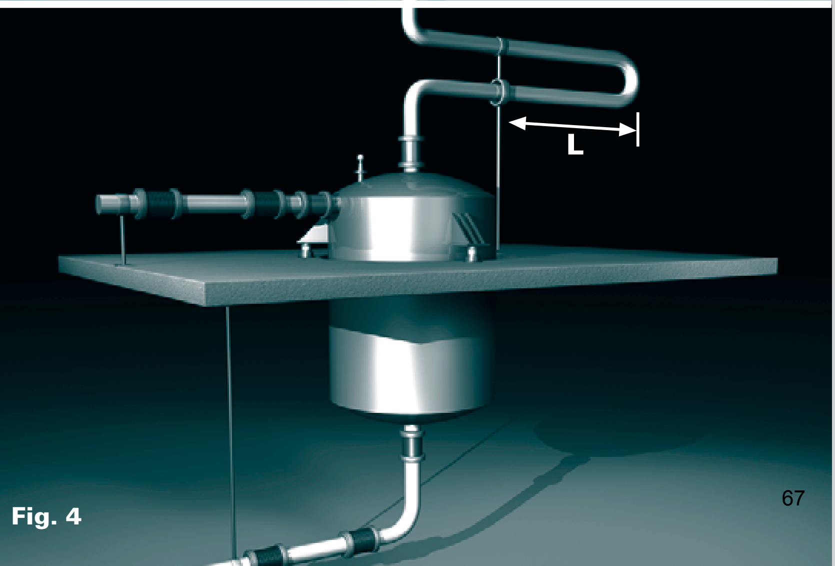


Fig. 4

Additional considerations:
Provide venting for cooling/heating jacket.
Pay attention to hopper heater fill degree.
Consider operating state (pressure, temperature, heating):

- Reactor and piping pressures cause weighing errors via pipe cross-section (provide pressure compensation, operate at zero-pressure, mount pipes horizontally)
- Pipes warm up through internal medium or radiating heat. Typical elongation: 0.1mm / 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 draft (provide insulating jacket or enclosure).
- Avoid thermal gradients, e.g. heat discharge from hopper via load cells (provide heat insulating plates).
- Protect load cell cable from mechanical damage (rodents) and moisture (run load cell cable in protecting tube).

Design/installation considerations

- Design platform construction with sufficient stiffness. Ensure deflection ≦ l/1,000.
- Run pipes and mount compensators horizontally.
- Compensate vertical lines as softly as possible.
- Provide potential equalisation between load cell housing and weighing 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 stress by thermal expansion, always use the genuine Schenck parts (foot plate and load cells of same material).
- To be able to calibrate and verify your scale, ensure that standard weights of min. 20% of its rated capacity can be applied. This is the prerequisite for legal-for-trade applications.

5) Hopper Scale Accuracy

Weighing accuracy is essentially determined by the right load cell rated capacity and quality.

Decisive parameters:

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

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

Keywords:

- Accurate mounting of supports
- Influence of shunt on repeatability
- Stiffness of mounting platform
- Agitator vibrations, centre of gravity displacement

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

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

With non-legal-for-trade weighing systems, when using RT load cells with 0.05% accuracy and proper installation in conjunction with Schenck weighing 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.

BV-D5007 GB

Schenck Process will be glad to back you up with:

- **Consulting**
- **Engineering**
- **Service**
- **Check**