RapidCal™ Tank Scale Calibration

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Engineering Recommendations

RapidCal™ Tank Scale Calibration is a new way to calibrate tank scales. It's similar to calibration with test weights but, in place of weights, it uses hydraulic cylinders to create the downward calibration force with that force measured by high-accuracy reference load cells.

Design guidelines
In this application manual, we show you some typical tank scales along with the provisions that must be made to attach RapidCal equipment. If you do not find a solution to your particular situation, please contact your METTLER TOLEDO sales representative for assistance.

Content

METTLER TOLEDO

1 Introduction

Attached pipes are the crucial difference between tank scales and other industrial scales such as platforms. As a tank scale is loaded, it deflects downwards pulling with it the attached pipes which apply an increasing upward force. This reduces the amount of weight registered by the load cells effectively reducing the sensitivity of the scale. Metrology can be seriously impacted if the scale is not designed and calibrated correctly.

To limit the impact, the general design approach is to limit scale deflection and pipe stiffness to reduce pipe forces and to make them linear and repeatable within limits commensurate with the scale accuracy required. However, even with the best efforts, some pipe force remains. This can be accounted for with the correct calibration method.

Ideally, calibration is done by applying test weights which exercise the scale support-structure and piping, thus simulating normal scale operation exactly (Figure 1 A). This exposes the piping effect on scale sensitivity allowing it to be accounted for in the calibration process, something that cannot be achieved with any form of electrical or theoretical calibration. However, test-weight calibration can be difficult and time-consuming. Additionally, test weights are expensive and may not be available, especially for higher-capacity scales.

METTLER TOLEDO's RapidCal method (Figure 1 B) uses the best aspects of test-weight calibration but without the disadvantages. Instead of pulling down with test weights, this method pulls down with RapidCal modules which consist of a tension hydraulic cylinder in series with a high-accuracy reference load cell to measure the calibration force applied. Reference load cells are factory-calibrated with test weights in advance, making the calibration traceable to international mass standards.

One to four RapidCal modules can be used, depending on the scale arrangement. They attach between anchor points on the scale and on the foundation directly below, using special hardware and threaded rod to adjust length. A hand-operated pump causes the hydraulic cylinders to retract, thus applying the downward force to the tank via the reference load cells. These

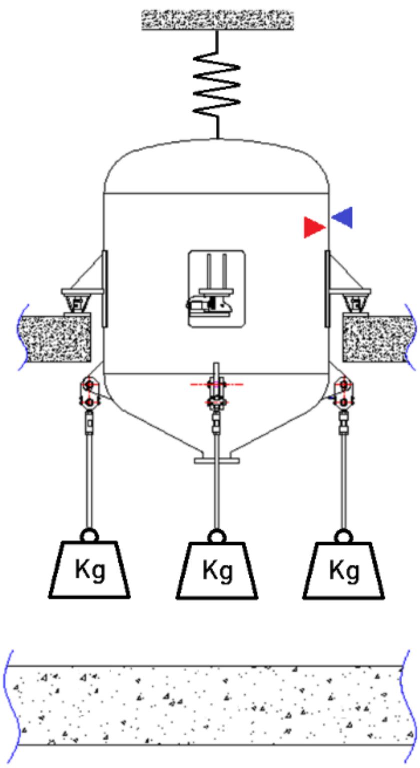


Figure 1 – Test weight vs. RapidCal
A. Calibration using test weights

Note: Tension springs represent the retarding effect of piping on the scale.

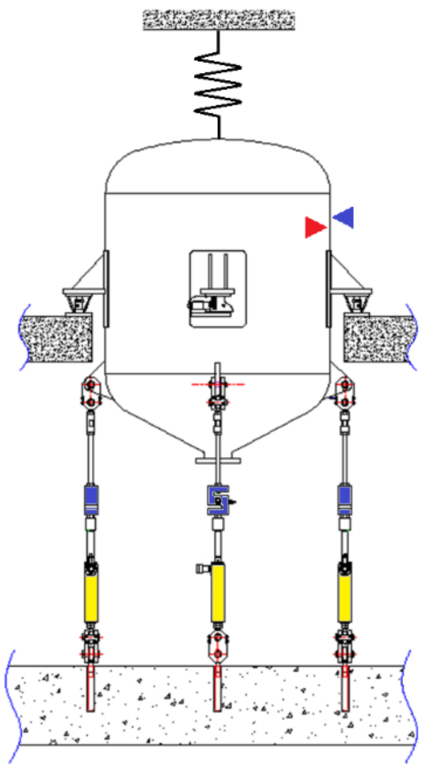


Figure 1 – Test weight vs. RapidCal
B. Calibration using RapidCal modules

load cells are connected to a separate terminal which monitors the process and provides the total load applied for calibration and/or adjustment.

The following sections discuss some typical installations with suggestions on how to provide the required anchor points. The suggestions are not exhaustive; please contact METTLER TOLEDO if you need further assistance.

For convenience we will refer to tanks throughout this document, however, RapidCal can be applied equally to reactor vessels, silos, bins, hoppers and other special scales.

2 RapidCal Calibration Equipment

The RapidCal method uses tension hydraulic cylinders to create the downward force that is measured by reference load cells. The equipment is modular; one to four calibration modules can be used depending on tank design and capacity.

One RapidCal module consists of:
- a tension hydraulic cylinder to apply the force
- an S-type reference load cell to monitor force, and
- mechanical hardware parts to complete the connections to the anchor points on the tank and floor (threaded rod, clevises, rod-ends, etc.).

Hydraulic pressure is generated using a simple hand pump. Pressure is distributed to the cylinders via manifold and flexible hoses.

Reference load cells are wired to a reference terminal which supervises the calibration process and provides a readout of the individual and total force applied to the tank.

RapidCal modules are available in two capacities and can be used to calibrate over a range as shown in the following table (Table 1):

Nominal capacity of RapidCal modules	**Calibration range, kg (lb)**	
	Minimum	Maximum
4 t	1,000 (2,200)	4,000 (8,800)
8 t	2,000 (4,400)	8,000 (17,600)

Table 1 – Calibration range of RapidCal modules

The minimum and maximum loads shown can be generated by one RapidCal module. Thus, the equipment can be used to calibrate tanks with capacities from 1,000 kg (2,200 lb) using one 4 t module to 32,000 kg (70,400 lb) using four 8 t modules.

The 8 t RapidCal module is physically bigger than the 4 t, and of course the tank and the foundation anchor points must be stronger. Hence the capacity to be used must be selected early in the design process.

Some notes on the calibration process:
- Calibration equipment is temporarily fitted during calibration. Only the anchor points remain permanently.
- The system requires AC power for the terminal but is otherwise standalone.
- There is no interference with the tank scale. For example, there is no need to remove anti-lift devices from the scale's weigh modules or to modify the scale electronics in any way.
- Should sensitivity adjustment be necessary, it is performed in the normal way through the scale terminal's keyboard.
- The equipment is assembled externally with no risk of contaminating the inside of the tank.
- The tank should be close to empty for calibration.

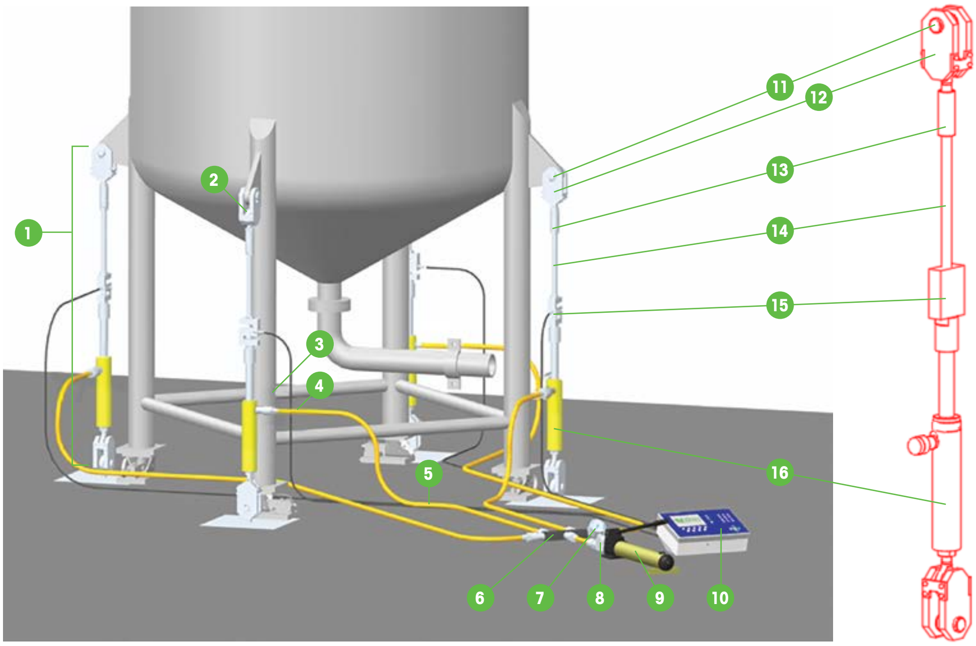


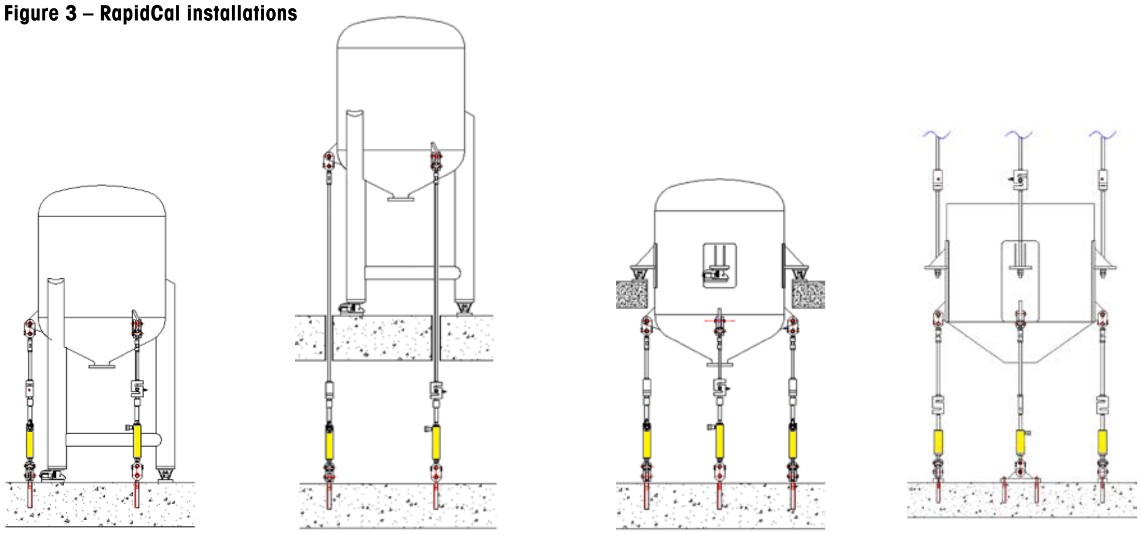
Figure 2 – Basic tank-scale design elements

METTLER TOLEDO's RapidCal method can be used with all tank configurations, some typical layouts include:

- Tank scales with legs mounted on 3+ compression weigh modules on a solid foundation (Figure 3, #1)
- As above but mounted on a steel structure or mezzanine floor (Figure 3, #2)
- Tank scales with 3+ support brackets mounted on compression weigh modules and supported on a steel structure or mezzanine floor, typical through-floor layout (Figure 3, #3)
- Tank scales suspended from an overhead structure on 1+ tension weigh module(s) (Figure 3, #4).

When a tank with pipes is mounted on a structure or mezzanine that deflects significantly when filled, it is important that RapidCal modules be anchored to an independent structure or foundation. This deflects the tank and its support in the same way that the normal applied load (or test weight for calibration) does. See illustrations #2, #3 and #4, Figure 3.

Figure 3 – RapidCal installations



#1: Legs on solid foundation/compression weigh modules

#2: Legs on structure or mezzanine floor/ compression weigh modules

#3: Support brackets on structure or mezzanine/compression weigh modules

#4: Suspended from overhead structure/ tension weigh modules

Figure 4 shows the basic dimensions and clearances required around the RapidCal module; it can be rotated ± 90° about its vertical axis compared to that shown. This is important in designing the scale and positioning ancillary equipment on the ground. Make provision also for technician access to assemble the RapidCal modules.

Dimensions, mm [in]	**RapidCal capacity**	
	4 t	8 t
A(1)	939 [37]	1045 [41.1]
B(2)	55–85 [2.17–3.35]	95–125 [3.74–4.92]
C(3)	55 [2.17]	65 [2.56]
D(4)	90 [3.54]	
E(5)	500 [20.0]	
F(6)	750 [29.5]	768 [30.24]
Threaded rod (used for extension(6))	M 20 x 1.5	M 30 x 2

(1) Dimension A is the minimum height requirement between the upper and lower anchor holes. It is based on the most versatile configuration of the RapidCal module, more compact arrangements are possible, please contact METTLER TOLEDO.
(2) Dimension B is the distance to the ground surface and varies depending on the type of lower anchor point used, see later.
(3) Dimension C is the minimum distance from the center line of the RapidCal module and the nearest point on the tank scale.
(4) Dimension D is the minimum clearance required on either side of the RapidCal module.
(5) Dimension E is the minimum clearance required for the hydraulic hose connection.
(6) Dimension F is the height of the RapidCal module when threaded rod is used to connect to a tank bracket, see below. Threaded rod extends upwards from this height to the tank bracket.

For RapidCal module details, refer to these drawings:

- 4 t: 30489501
- 8 t: 30489502

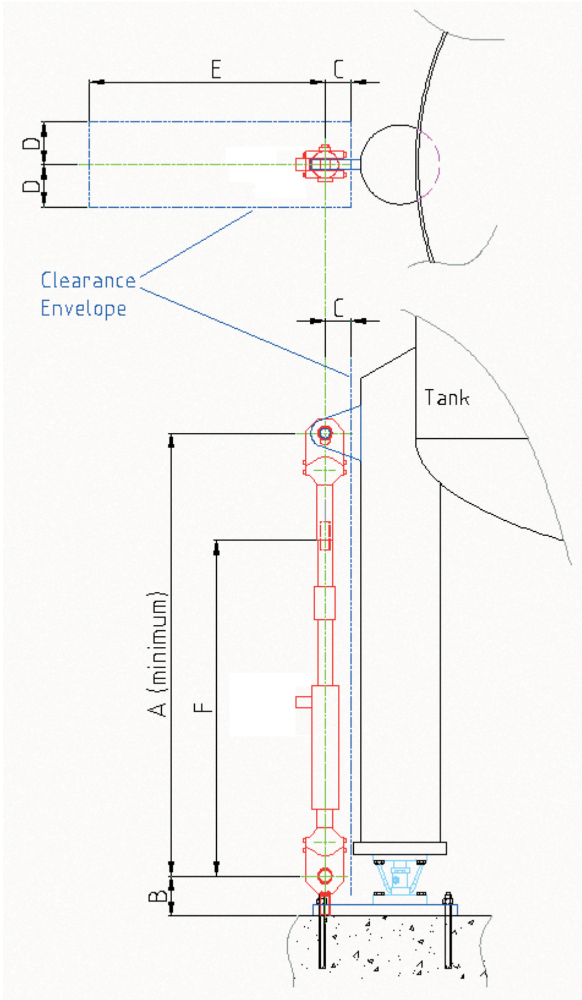


Figure 4 – Basic dimensions and clearances

Various tank and floor anchor-point designs are detailed in the text that follows. These designs can be combined to suit the particular scale as the hardware used to attach the RapidCal modules allows a high degree of flexibility.

Your METTLER TOLEDO representative will provide drawings in various formats so that the RapidCal modules can be incorporated into your design.

3 Tank Requirements for RapidCal

While tanks can be retrofitted to accommodate METTLER TOLEDO's RapidCal equipment, it will be much more convenient and cost-effective to make provisions at the initial design stage.

There are three main steps during design and installation:
1. Select the number and capacity of the RapidCal modules to be used.
2. Select the type and placement of T-anchor points on the tank.
3. Select the type and placement of B-anchor points on the floor/base.

This section will guide you through these steps. For each step, certain information is needed and, based on that, the design will be determined. This is shown in Figure 5 below which shows the basic process, while the pages that follow provide a more detailed explanation.

Step 1 – Select the RapidCal modules

Input

Scale data:
- Number of weigh modules
- Scale capacity

Output

RapidCal module data:
- Number to use
- Capacity (4 t or 8 t)
- Dimensions and drawings

Step 2 – Select T-anchor points on the tank scale

Input

Scale data:
- Mounting style (on floor, structure/ mezzanine or hanging)
- Dimensions

Output

Scale anchor details:
- Lug detail (on tank wall or leg)
- Support bracket requirements
- Dimensions and drawings

Step 3 – Select B-anchor points at the base base

Input

Scale foundation data:
- Foundation type (concrete, metal, sub-frame, etc.)
- Anchor adjacent to leg (Yes/No)?

Output

Foundation anchor details:
- Threaded hole (in concrete anchor, sub-plate or anchor-plate)
- Lug on sub-frame
- Dimensions and drawings

Figure 5 – Design steps

3.1 – Step 1: Choose number and capacity of the RapidCal modules

METTLER TOLEDO recommends the use of three or four RapidCal modules on scales with three or four weigh modules respectively, regardless of weigh-module type (i.e., tension or compression). This recommendation applies to all scale mounting configurations including tanks with legs mounted on compression weigh modules and those with support brackets mounted on tension or compression weigh modules. So in general:

N (the Number of RapidCal modules used) = Number of tank support points

After deciding on the number of RapidCal modules, select the capacity (4 t or 8 t) that best suits the scale. Scales are typically calibrated in the range zero to scale capacity*, hence, the combination of three or four RapidCal modules should be able to apply scale capacity during the calibration process. Calculate the max. calibration force (CFm) to be applied by each RapidCal module during calibration, as follows:

CFm (kgf) = scale capacity (kg)/N
CFm (Newtons) = 9.81 x scale capacity (kg)/N
CFM (lb) – scale capacity (lb)/N

The following table (Table 2) lists the max. force that each module can apply. Pick the lowest capacity module that can apply the CFm calculated above.

* Scale capacity is the maximum weighing capacity of a scale; scales are designed to weigh this applied load regardless of scale dead weight. Scale capacity is sometimes referred to as maximum capacity, max. or live load.

RapidCal module capacity, nominal		**4 t**	**8 t**
Max. force the module can apply	kgf	4,000	8,000
	Newtons	40,000	80,000
	lb	8,800	17,600

Table 2 – RapidCal module capacity

Example 1 (kgf)
If a tank has a scale capacity of 5,000 kg and sits on three weigh modules, then:
1. Use three RapidCal modules (N = 3)
2. CFm = 5,000 / 3 = 1,667 kgf. The lowest capacity RapidCal module that can apply this force is the 4 t, select it.

Example 2 (Newtons)
If a tank has a scale capacity of 30,000 kg and sits on four weigh modules, then:
1. Use four RapidCal modules (N = 4)
2. CFm = 9.81 x 30,000 / 4 = 73,600 Newtons. The lowest capacity RapidCal module that can apply this force is the 8 t, select it.

Example 3 (lb)
If a tank has a scale capacity of 50,000 lb and it sits on four weigh modules, then:
1. Use four RapidCal modules (N = 4)
2. CFm = 50,000 / 4 = 12,500 lb. The lowest capacity RapidCal module that can apply this force is the 8 t, select it.

Note that CFm is also important in the design of the anchor points, each one must withstand this force during the calibration process with a suitable factor of safety.

RapidCal can be used for tanks with scale capacity in excess of 32,000 kg [70,400 lb], if calibration at less than scale capacity is acceptable. RapidCal can also be combined with the material substitution method: with just one substitution, 64,000 kg [141,000 lb] can be reached.

Contact METTLER TOLEDO for application assistance if you wish to use less than three RapidCal modules.

3.2 – Step 2: Design T-anchor points on the tank scale

Once the RapidCal module capacity is chosen, the T-anchor points (that is, the anchor points on the tank scale) can be designed. Figure 6 below provides a number of alternatives. A discussion of the pros and cons of each design follows along with corresponding drawing references. Note that the RapidCal modules (parts supplied by METTLER TOLEDO) are shown in red in the following drawings.

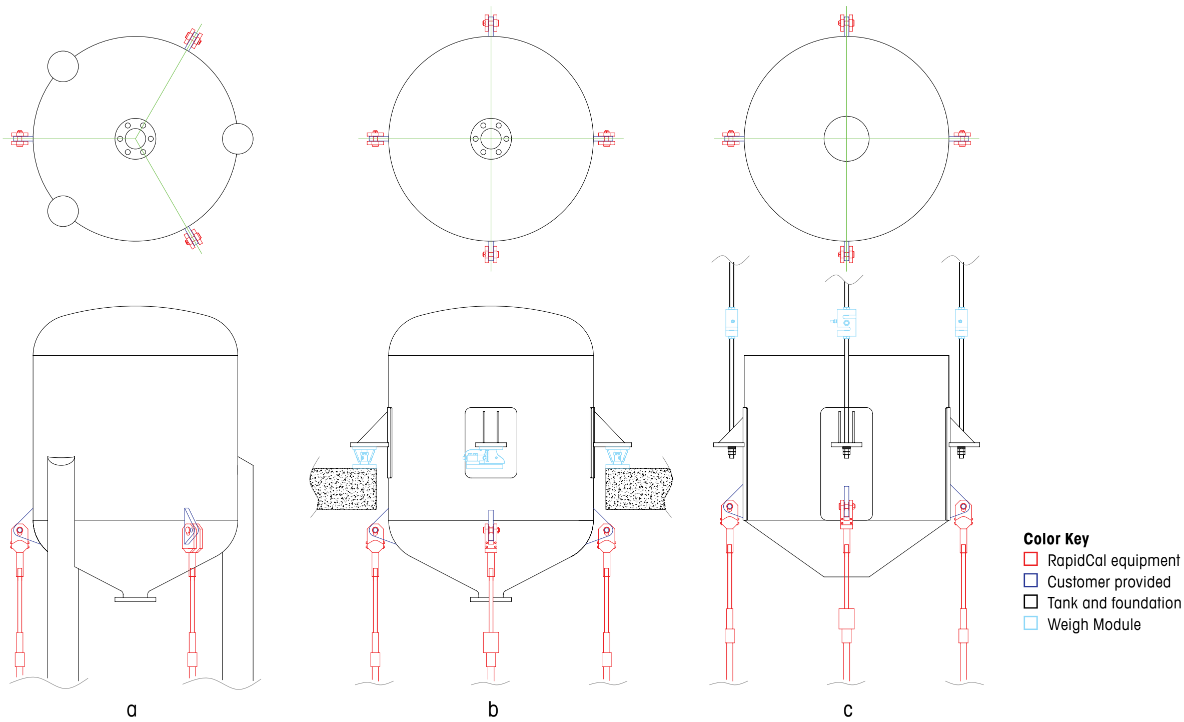


Figure 6 – T-anchor points
#1: Lug welded on the tank wall

Figure 6, #1: Lugs welded on the tank wall
This is the general method that works in all situations regardless of how the scale is supported:

- When the tank stands on legs (#1a above) the lugs will be positioned equidistant between the legs at 90° (four legs) or 120° (three legs) to each other. The legs, weigh modules and lugs should all be displaced symmetrically around the scale's vertical center line. See Section 4.
- When the tank has support brackets for mounting, the lugs will generally be placed directly under the weigh modules. Illustration #1b is an example of through-floor mounting on compression weigh modules; the lugs can be positioned on the bottom surface if they would interfere during installation. Illustration #1c is an example of tension mounting from an overhead structure (not shown). Again, the support brackets, weigh modules and lugs should be placed symmetrically relative to the scale's vertical center line.
- Position the lugs vertically at a point that is inherently strong (e.g., a corner) and/or reinforce the wall as required.
- These lugs are often used (in combination with lugs on the tank's top) for lifting during installation. Note that other considerations may apply if used in this way, see Section 4.
- In contrast to the situation in #2, lugs positioned as described here could be used for hanging weights for calibration or verification, if that were ever desired in the future.

For tank lug details, refer to these drawings:
4 t: 30489501-2
8 t: 30489502-2

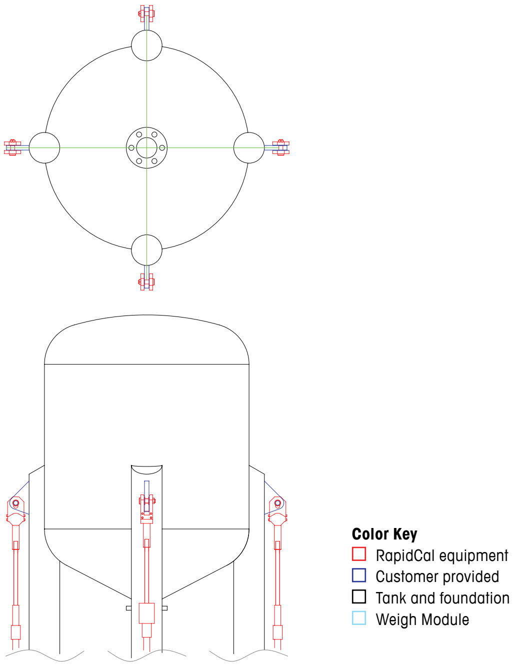


Figure 6 – T-anchor points
#2: Lug welded on tank leg

Figure 6, #2: Lugs welded on the tank leg
This method applies to tanks with legs only, and has a number of advantages:

- A major advantage of this lug position is that it puts the RapidCal module's lower anchor point adjacent to the weigh module and they can be incorporated into one assembly. Further, the dead weight of the tank can be used to reduce the pull-out force on that lower anchor point. This is an advantage in new and especially retrofit situations where the floor would not have been designed to support the lower anchor point.
- Another advantage in retrofit situations is that welding the lug to the leg is less critical compared to welding to the body of the tank.
- If the tank is to have an insulated jacket, then this position for the lugs is typically farther outboard and easier to keep clear of the insulation without a large overhang from the lug's weld-line.
- Position the lugs high on the legs (ideally as shown in #2 where the leg is stiff) to minimize lateral deflection of the leg at the weigh module. Reinforce the leg internally or externally adjacent to the lug, as required. The lug and cap on the leg might be incorporated for extra rigidity. Position the lugs symmetrically relative to the scale's vertical center line, see Section 4.
- If these lugs are to be used in lifting the tank, see Section 4.
- A disadvantage of having the lug close to the leg is that it makes it difficult to hang test weights from it, should that ever be desired.

For leg-lug details, refer to these drawings:
4 t: 30489501-1
8 t: 30489502-1

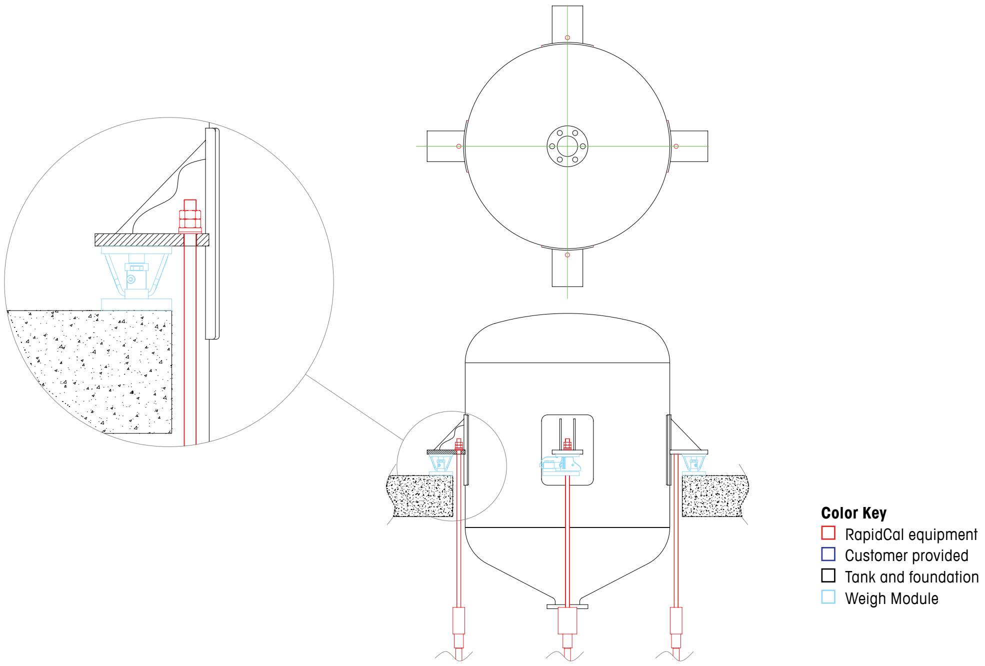


Figure 6 – T-anchor points
#3: Connection directly to support bracket

Figure 6, #3: Connection directly to support bracket
This method works well for any tension or compression arrangement with support brackets that project radially from the tank:

- When the tank is supported on support brackets in compression, as in #3 or in tension as in #1c, then the threaded rod of the RapidCal module can pull directly on the horizontal plate of the bracket. This is a very simple method that requires just an extra hole in the bracket for the threaded rod to fit through. The rod protrudes above the horizontal plate and is fitted with a spherical washer set (to accommodate misalignment) and double nuts, see detail inset in #3 above.
- This method could be used with any scale with a rigid horizontal flange to which the RapidCal modules can attach.
- Again, the support brackets, weigh modules and attachment holes should be displaced symmetrically relative to the scale's vertical center line, see Section 4.
- The attachment hole in the mounting bracket must be vertically above the foundation mounting point (within a certain tolerance, see later) without obstruction in between. This is particularly important in the case of through-floor installations (as in #3) where the threaded rod must pass down in the annular space between the tank and mezzanine floor.

For bracket details, refer to these drawings:
4 t: 30489501-3
8 t: 30489502-3

3.3 – Step 3: Design B-anchor points at the base of the scale

Once you have decided where the RapidCal modules will connect to the tank scale, you can design the B-anchor (base anchor) points to which they will be attached. One important consideration is how to ensure that the RapidCal modules stand plumb within a certain tolerance. This consideration has influenced the choice of approaches detailed in the following table and discussion (see also Section 4 where it is discussed in greater detail).

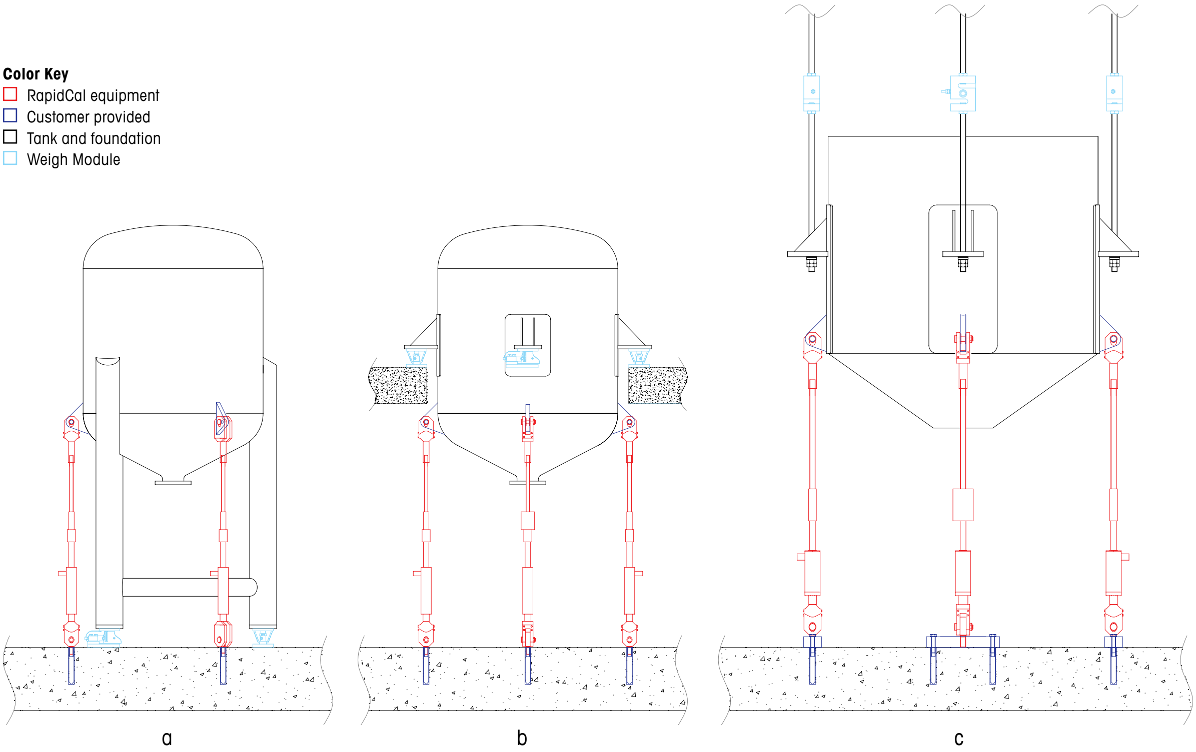


Figure 7 – B-anchor points
#1: On solid concrete foundation

Figure 7, #1: On solid concrete foundation
In this situation, the lower anchor point must attach directly to a concrete foundation. Even in #1a, the RapidCal module is centered between legs on the three-legged tank and must attach directly to the foundation:

- The most convenient method is to fully install the tank in its final position and with a plumb bob, mark the lower anchor point on the concrete directly below the lug. Then drill the concrete and embed an internally-threaded sleeve using an adhesive anchoring system. The anchor supplier can also provide the equipment necessary to drill reinforced concrete. The sleeve is inserted flush with the floor surface and can be plugged when not in use. For the calibration process, a rod-end is screwed into the sleeve and the RapidCal module attaches using a clevis. This is the method illustrated in #1a and #1b; there is one sleeve per anchor point and this is suitable for the 4 t RapidCal module to its full capacity.
- Figure #1c illustrates the same anchoring method but using two sleeves per anchor-point, making it suitable for the 8 t RapidCal module used to its full capacity. In this case, an anchor plate with two mounting holes is used to distribute the tensile force over two anchors. For the calibration process, a rod-end is screwed into the center of the anchor plate and the RapidCal module attaches using a clevis. As described for Figure #1a and #1b above, the anchor plate is located after scale installation is complete and is used as a template to locate the sleeves in the concrete. The anchor plate is temporarily fastened in place during the calibration; when not in use it can be removed and the sleeves plugged.
- The major advantage of this method is that the lower anchor point can be aligned well with the tank lugs after it has been installed. Clearly the concrete foundation must be designed with this anchor method in mind. In a retrofit situation, the foundation details must be known and evaluated for suitability.
- There are other methods of accomplishing the same result. For example, a threaded sleeve or a plate

with a threaded hole can be embedded in the concrete when it is poured. But it will be difficult to get these positioned correctly ahead of time.

- This method has the advantage that the B-anchor points are away from the weigh modules with no danger of disturbing the scale during calibration by changing the load introduction conditions around the weigh modules, see Section 4.

For details of attachment to a solid foundation, refer to these drawings:
4 t: 30489501-4
8 t: 30489502-4

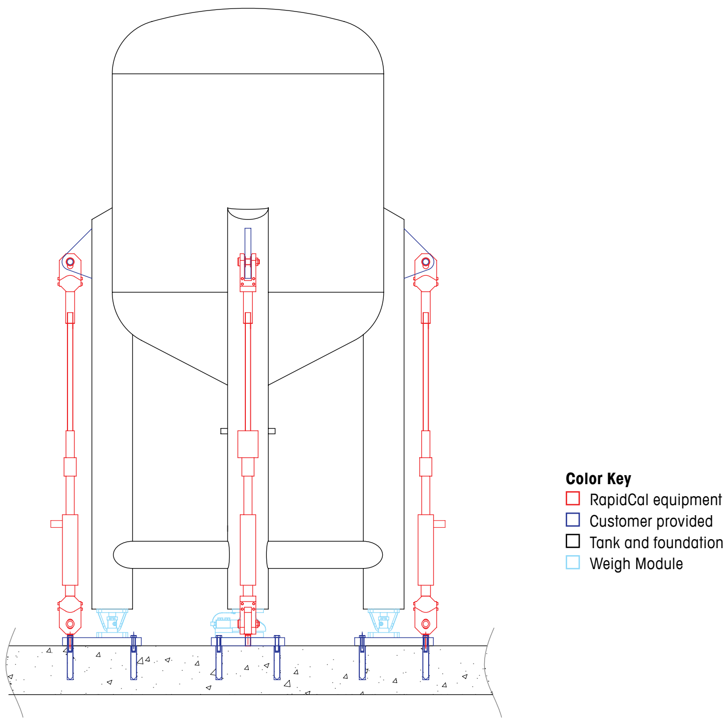


Figure 7 – B-anchor points
#2: On solid concrete foundation adjacent to tank legs

Figure 7, #2: On solid concrete foundation adjacent to tank legs

This is a very common situation where a tank on legs is mounted on compression weigh modules on a rigid foundation:

- Legs are convenient mounting points for T-anchors but this is also very convenient for the B-anchors as we can take advantage of the downward forces through the weigh module to at least partially restrain the B-anchor points.
- As illustrated in #2 above, the weigh module sits on and is screwed to a larger sub-plate which in turn has four holes for anchoring to the concrete foundation. The sub-plate also has a threaded hole for attachment of a rod-end and hence the lower clevis of the RapidCal module.
- The sub-plate controls the dimension from its threaded hole (for attachment of the RapidCal module) to the hole-pattern for weigh module mounting and hence to the center line of the leg and its T-anchor above. Hence the sub-plate, a machined part, determines fully and accurately the vertical alignment of the T- and B-anchor points.
- For installation, the sub-plates would be mounted to the weigh modules which in turn would be mounted to the tank. The sub-plates can float until the tank location is satisfactory, at which point they can be used as templates to drill the concrete for expansion or adhesive anchors.
- For calibration, a rod-end is temporarily screwed into the sub-plate's threaded hole and the RapidCal

module is attached using a clevis. The threaded hole can be plugged when not in use.

- During calibration, the RapidCal modules produce a tensile force between the sub-plates and lugs on the tank above. This tends to lift the sub-plates but this is resisted partially by the calibration force and tank dead weight acting down through the leg and weigh module. The sub-plates must be anchored to the concrete to resist the uplift force, but this can be much reduced compared to case #1 above, depending on the ratio of tank dead weight to scale capacity (which determines the calibration force). For a detailed description, see the drawings referenced below. Note that in designing the anchoring system for the sub-plate, there are usually other forces to be considered, such as those resulting from wind or seismic activity.
- This method is very suitable for retrofit situations, as the T-anchor welding to the leg is less critical, as mentioned previously. Also, the uplift forces on the foundation are reduced, as discussed above.
- The sub-plates must be shimmed and/or grouted and rigid. The plate must not lift or deflect during calibration as this could influence scale performance just as you are trying to calibrate it, see Section 4.

For details of attachment to a weigh module sub-plate, refer to these drawings:
4 t: 30489501-5
8 t: 30489502-5

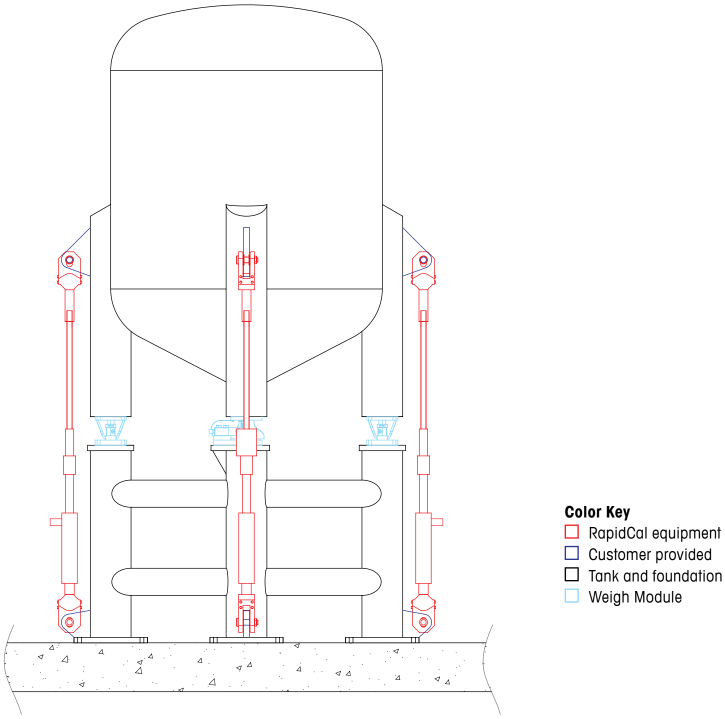


Figure 7 – B-anchor points
#3: On structural sub-frame under tank legs

Figure 7, #3: On structural sub-frame under tank legs

Sometimes a tank's legs are split and the weigh modules moved up and away from the floor as shown in #3 above. This can be done for various reasons, for example, to avoid inundation (e.g., a tank inside a bund subject to flooding), to facilitate heavy wash-down, or for hygienic reasons. As it relates to RapidCal:

- A frame such as this must be rigid and self-supporting in order to provide the required support to the weigh modules. Taller frames will often have X bracing for support.
- A braced frame provides ideal support to the B-anchors without imparting any additional uplift or compressive forces to the concrete foundation during calibration.
- Minimize the overhang of the mounting flanges (above and below the weigh modules) to minimize the possibility of interference with the RapidCal modules. This will allow the modules to be tucked-in close to the leg, thus minimizing the moment produced by the RapidCal modules.
- Stiffen the tank legs if they are long and likely to deflect laterally under normal tank loading or during calibration.
- There are many constructions possible for such a frame. For example, it could be a simple X frame made of I-beam or simply a steel plate lying on the floor under the weigh modules.

For details of attachment to a sub-frame, refer to these drawings:
4 t: 30489501-6
8 t: 30489502-6

Table 3 summarizes the possible combinations of T- and B-anchors. Note that some B-anchors have up to three possible T-anchors listed-in decreasing order of likelihood that they will be used.

If you don't find suitable anchor points either on the tank or on the floor, please contact METTLER TOLEDO for assistance.

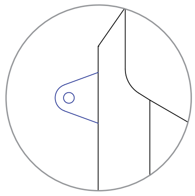
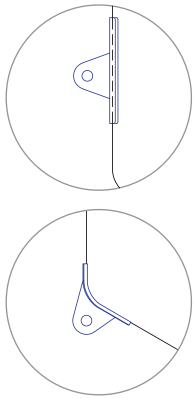
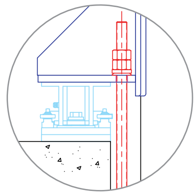
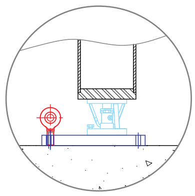
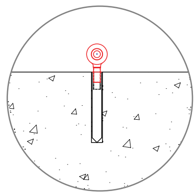
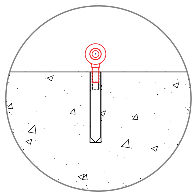
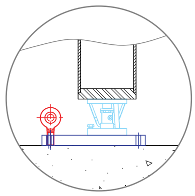
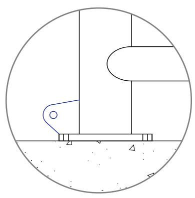
Tank T-anchors	Illustration				
	Description		Leg-Lug	Wall-lug	Bracket
	Drawing	4 t	30489501-1	30489501-2	30489501-3
		8 t	30489502-1	30489502-2	30489502-3
Possible foundation B-anchors	Illustration most likely				
	Description		Sub-plate	Concrete	
	Drawing	4 t	30489501-5	30489501-4	
		8 t	30489502-5	30489502-4	
	Illustration				
	Description		Concrete	Sub-plate	
	Drawing	4 t	30489501-4	30489501-5	
		8 t	30489502-4	30489502-5	
	Illustration least likely				
	Description		Sub-frame		
	Drawing	4 t	30489501-6		
		8 t	30489502-6		

Table 3 – Possible combinations of T- and B-anchors

4 General Considerations

Forces on anchor points
During calibration, each RapidCal module applies the same downward force CFm (see section 3.1) to each anchor point on the scale. Locally the anchor points must be able to withstand the CFm force, and the tank and its support structure must be able to withstand the sum of all such forces applied simultaneously.
At the same time, each RapidCal module applies an upward force to each anchor point on the foundation, sub-frame, etc., to which they are attached. Locally the anchor points must be able to withstand the CFm force, and the foundation, sub-frame, etc., must be able to withstand the sum of all such forces applied simultaneously.
A suitable factor of safety should be applied throughout. The owner/operator is responsible for ensuring the structural integrity of the installation and its ability to withstand the forces applied during the RapidCal process.

Lugs used also for lifting
If the same lugs are to be used to lift a tank during installation and for RapidCal thereafter, design the lugs for the worst case loading condition. In particular, the dead weight of reactor vessels can be many times the scale capacity which determines the CFm as discussed above. So lugs designed for RapidCal may not be strong enough for lifting.

Do not interfere with the scale's weigh modules
The RapidCal modules should load the tank without changing the loading conditions at the scale's weigh modules, as far as possible. For example, mounting brackets on the side of a scale will inevitably deflect when the scale is loaded; you want the RapidCal modules to cause the same deflection during calibration. Refer to Figure 8, both support brackets will tend to rotate clockwise when the tank is filled with liquid. The placement of the RapidCal module in the right hand illustration will best simulate actual loading conditions, causing the bracket to rotate clockwise. In the left hand illustration the RapidCal module will have the opposite effect, tending to rotate the bracket counter-clockwise using the weigh module as a fulcrum-point. Take care also when anchoring to sub-plates under compression modules (as in drawings 30489501-5 and 30489502-5), anchor the sub-plates securely to the foundation to minimize lifting during calibration.

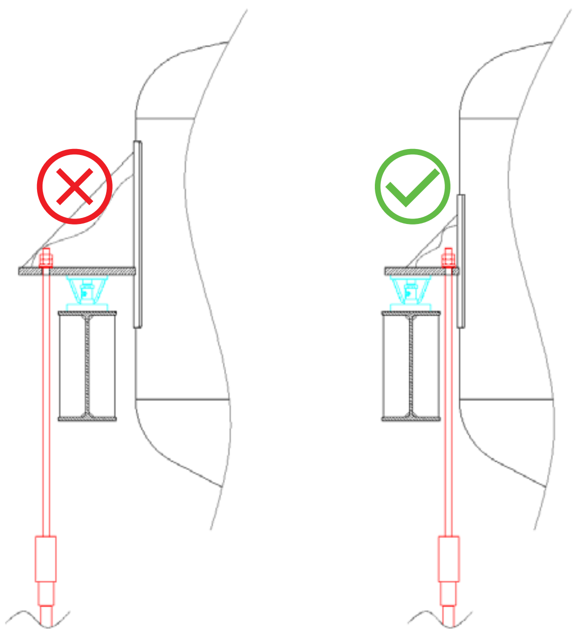


Figure 8 – RapidCal module attachment to support brackets

Symmetrical placement of anchor points
The RapidCal modules should load the tank in a way that simulates the loading conditions that prevail when the tank is filled with material. The RapidCal modules apply a parallel force system to a tank, and you want the resultant of that force system to be coincident with the vertical center-line of the tank, where the center of gravity of the weighed material is located. Symmetry is key. This is important because typically tank scales are not shift (eccentricity) adjusted at the time of installation.

Position all lugs at the same radial distance from the tank's vertical center line, and displaced rotationally at 120° (three RapidCal modules) or 90° (four RapidCal modules) around the tank, as shown in Figure 9. For non-symmetrical tanks, contact METTLER TOLEDO for assistance.

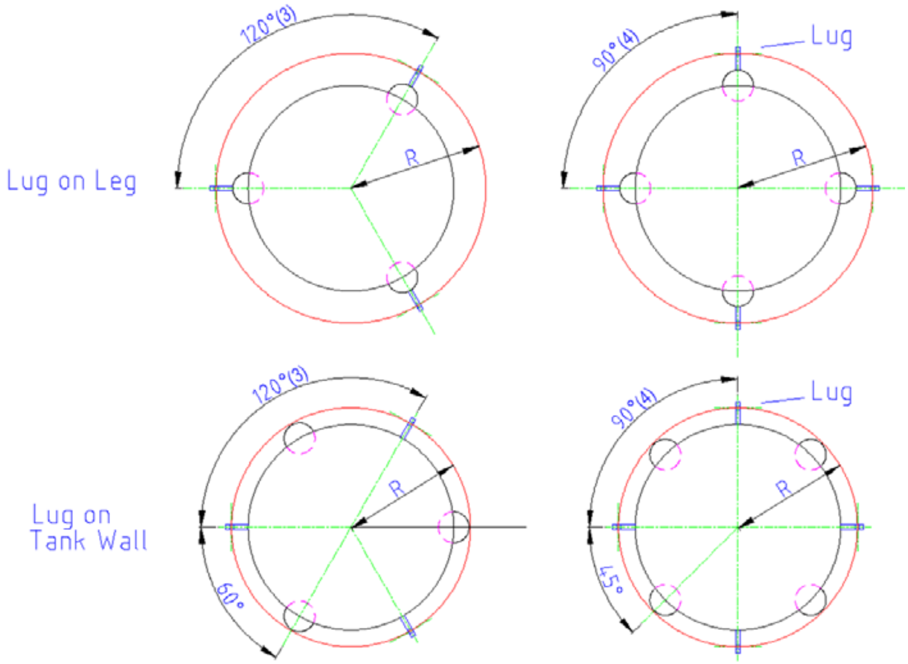


Figure 9 – Symmetrical placement of T-anchor points

Vertical alignment of anchor points
For optimal RapidCal performance, each anchor point on the tank and its corresponding anchor point on the foundation should be aligned vertically with a maximum deviation of 0.5°. In other words, each RapidCal module must stand vertically within 0.5° when installed between the tank and foundation anchor-points. It is recommended to check alignment with a plumb-bob on initial installation and before each RapidCal calibration.

If a lug is used as the T-anchor point, thread the string of the plumb-bob through the hole of the lug, position the bob just above the B-anchor and tie the free end of the string at the bottom near the bob, as illustrated in Figure 10 below. Pull down on the bob to make sure it is hanging freely and centered.

The table below provides the maximum allowed dimension R, measured from the vertical center line of the B-anchor to the tip of the bob, and hence, the center of the T-anchor above. This value obviously increases with increasing vertical distance H between T- and B-anchor points, as tabulated. Another way of stating this is that the installation is acceptable if the vertical center line of the B-anchor is located on or inside a circle of radius R centered on the tip of the plumb-bob.

Metric		Imperial	
H (m)	Max. R (mm)	H (ft)	Max. R (in)
0.7	6.1	2.25	0.24
0.8	7.0	2.5	0.26
0.9	7.9	2.75	0.29
1	8.7	3	0.31
1.1	9.6	3.25	0.34
1.2	10.5	3.5	0.37
1.3	11.3	3.75	0.39
1.4	12.2	4	0.42
1.5	13.1	4.25	0.45
1.6	14.0	4.5	0.47
1.7	14.8	4.75	0.50
1.8	15.7	5	0.53
1.9	16.6	5.25	0.55
2	17.5	5.5	0.58
2.1	18.3	5.75	0.60
2.2	19.2	6	0.63

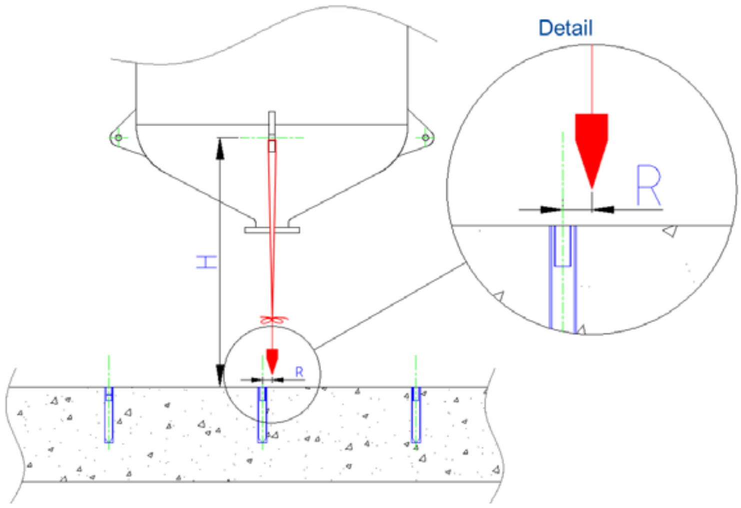


Figure 10 – Use of plumb-bob
The maximum R dimension can be calculated as follows for any value of H:
Metric: Max. R (mm) = 8.7*H (m)
Imperial: Max. R (in) = 0.105*H (ft)

Calibration of tanks on a deflecting structure
When a tank with attached pipes is mounted on a mezzanine or steel structure that deflects when the tank is filled, then special care needs to be exercised in calibrating the scale. Figure 11 illustrates the situation but with the structural deflection greatly exaggerated. When the tank is filled at the right, it deflects downwards along with the structure. The pipes act like cantilever springs retarding the deflection of the tank, and the upward forces they apply to the tank can be very significant, depending on their stiffness. So the scale's weigh modules can only detect the weight added to the scale minus the pipe force. And the pipe force is unknown, any form of theoretical or electrical calibration method cannot account for this. This is also true of all forms of compression hydraulic calibration methods (push-up or push-down) as they do not exercise the pipes and are blind to the effects. One method that does work correctly is calibration with test weighs hung from the tank. RapidCal does work in this situation also, but the modules need to attach to an independent frame or foundation, as shown on the right of Figure 12.

To recap, this is not an issue at all if there is no pipe force (e.g., a typical hopper scale) and/or the structure is rigid. It becomes of increasing concern with increasing scale deflection and increasing pipe stiffness. More generally that combination is a major concern when it comes to scale performance generally, see METTLER TOLEDO's Weigh Module Systems Handbook for more details.

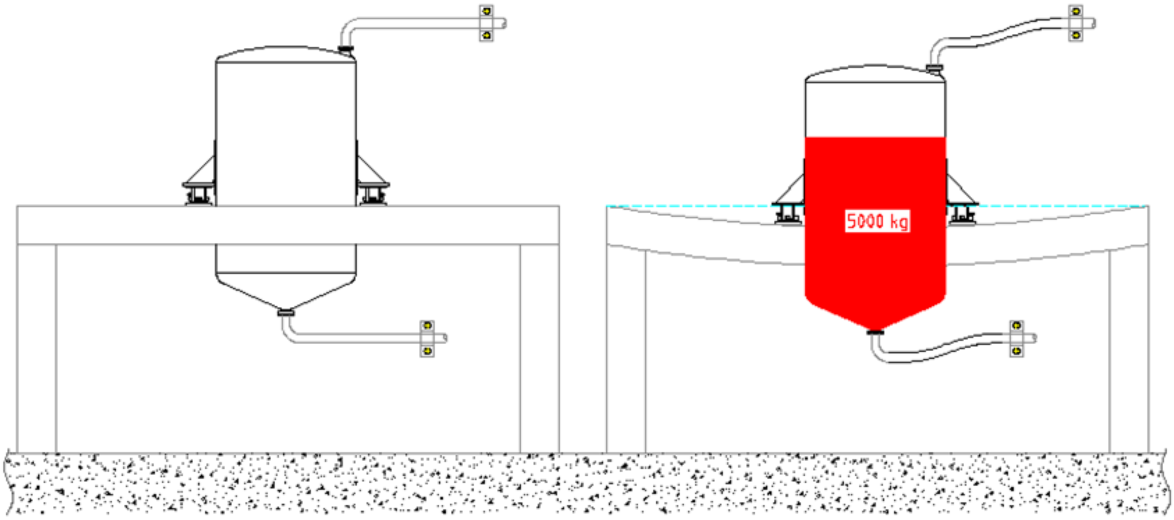


Figure 11 – Scale deflection and pipe forces

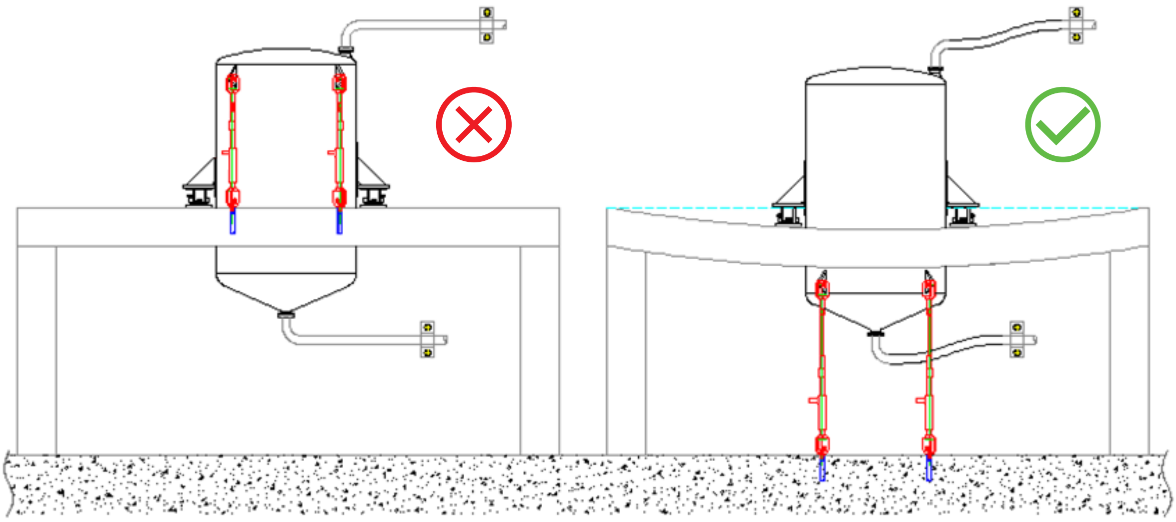


Figure 12 – Calibration arrangement

5 Specifications

RapidCal specifications are shown in the following table (table 4):

Parameter	**RapidCal module, 4 t**	**RapidCal module, 8 t**
Nominal capacity	4 t	8 t
Max. force per RapidCal module	4,000 kgf	8,000 kgf
	40,000 N	80,000 N
	8,800 lb	17,600 lb
No. RapidCal modules used	1–4	
Scale capacity range*	1–16 t	2–32 t
Calibration uncertainty	0.1%	
Traceability	Complete traceability chain, starting with certified METTLER TOLEDO test weights	
Certifiable	Yes	
Calibration temperature range	5–35 °C (41–95 °F)	
Scale type	Tank, reactor vessel, hopper, silo, bin	
Scale mounting	Compression and tension scales mounted on concrete foundations and steel structures or mezzanine floors	
Calibration type	Tension pull-down method, hydraulic cylinders with reference load cells	
Hydraulic fluid	Food grade Mobil SHC Cibus 32	
Hazardous area	Zone 2/22 (ATEX) and Class I, II, III Division 2 (USA)	

Table 4 – RapidCal specifications
* to remain within the specified Calibration Uncertainty

Disclaimer
In this document general guidelines are provided for how to integrate RapidCal equipment into your scale for calibration purposes. However, METTLER TOLEDO cannot predict the many different field situations in which this equipment will be used. It is the sole responsibility of the scale owner to make sure the scale, support structure and/or foundation are designed to withstand the forces and torques created during the calibration process. METTLER TOLDEO cannot assume any liability for loss or injury during the calibration process and this guideline does not extend our warranty in any way.

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