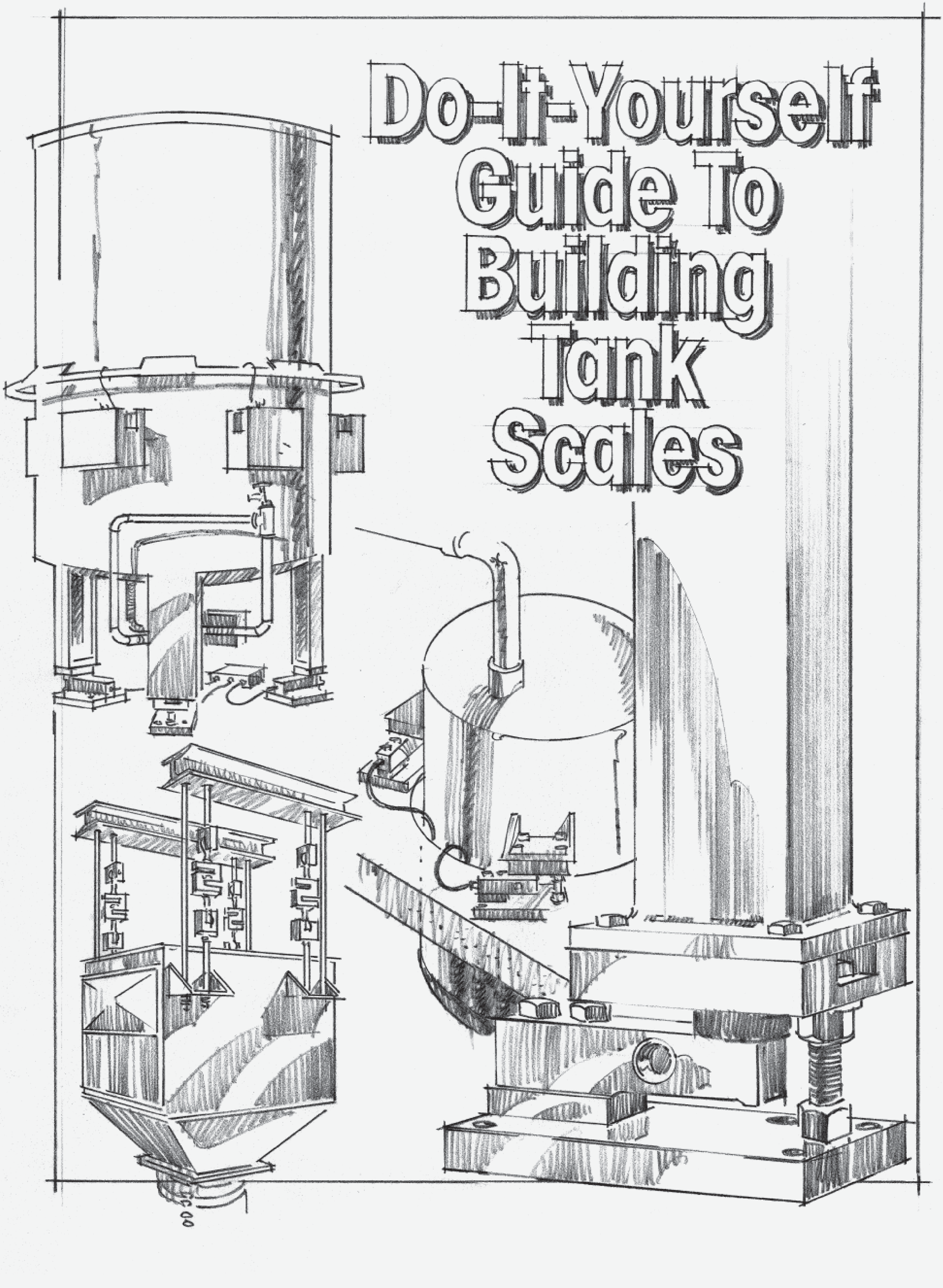
Do-It-Yourself Guide To Building Tank Scales



❑ PREFACE

Imagine going to the store to buy a bathroom scale so you can monitor the results of your diet. The clerk hands you a bag of wiring, a mechanical device which he says includes the world's finest load cell, and an indicator that will show how much you weigh—if you put everything together properly. He says the scale you build should work just fine because of the superior quality of the load cell. He sends you away with his good wishes and a request to call and let him know how everything works out.

Far-fetched? For a bathroom scale perhaps. But that's basically the situation you face if you need a tank scale. Nobody makes tank scales, so you can't buy one. You can only buy some of the components—load cells, weigh modules, cabling, signal processors, and indicators. The rest you have to design and build yourself. If ever there was a do-it-yourself project, this is it.

The component suppliers will not…indeed, can not…make any representations about the performance of the scale you build. In fact, you won't know how good your tank scale is until it's finished and tested. And there are no guarantees.

That being said, we should also point out that people build tank scales every day, and the vast majority of them work just fine. We want yours to be in that majority, so we wrote this booklet summarizing the basic concepts, the important steps in the process, and the most obvious pitfalls. We want you to be able to ask the right questions of the right people at the right times.

We don't claim to be totally objective, but we think you'll be able to distinguish easily between the generic DOs and DON'Ts and any statements we make about Mettler Toledo products, expertise, or service.

We can also help you with your specific tank scale. Please contact your local authorized Mettler Toledo representative for all your weighing projects.

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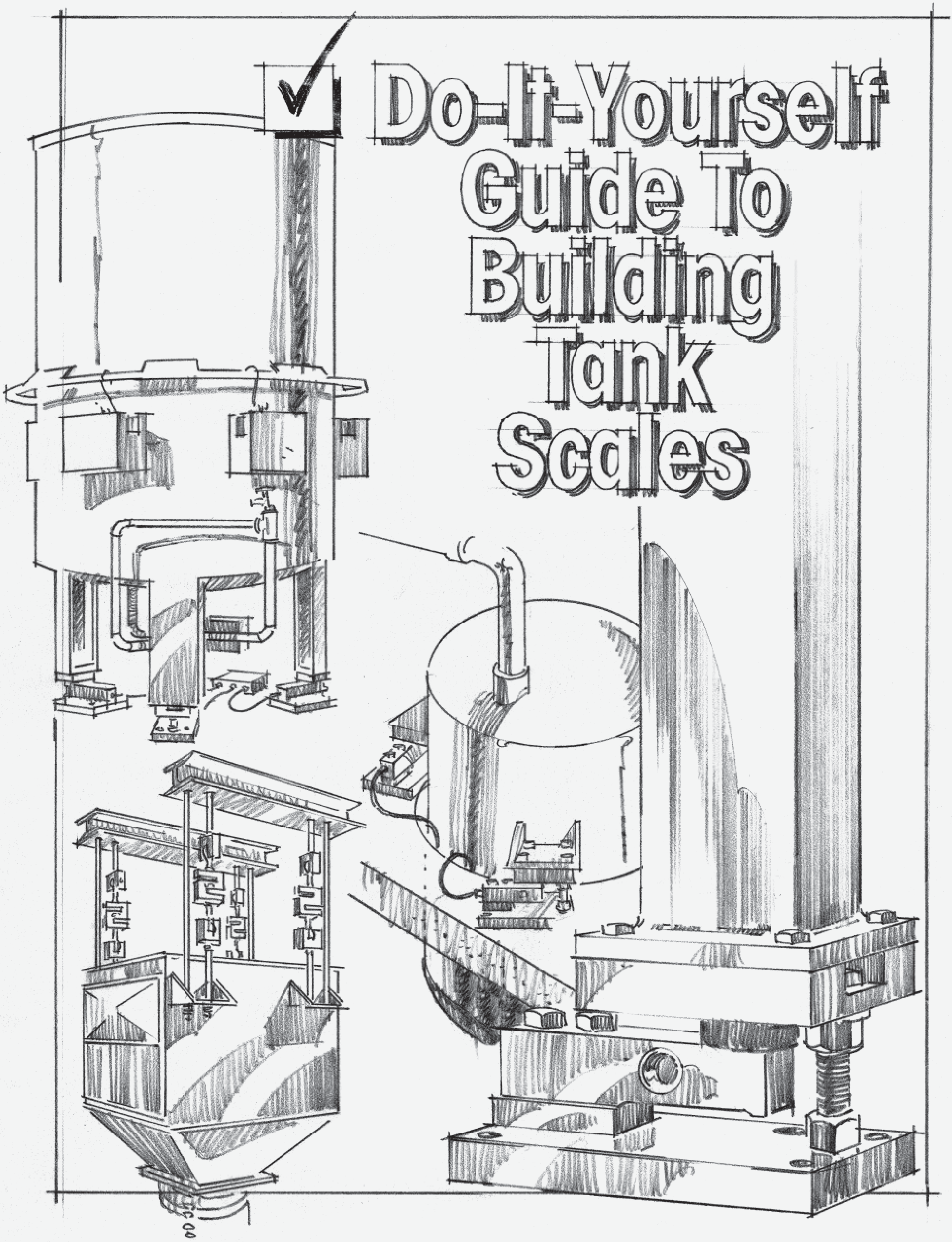

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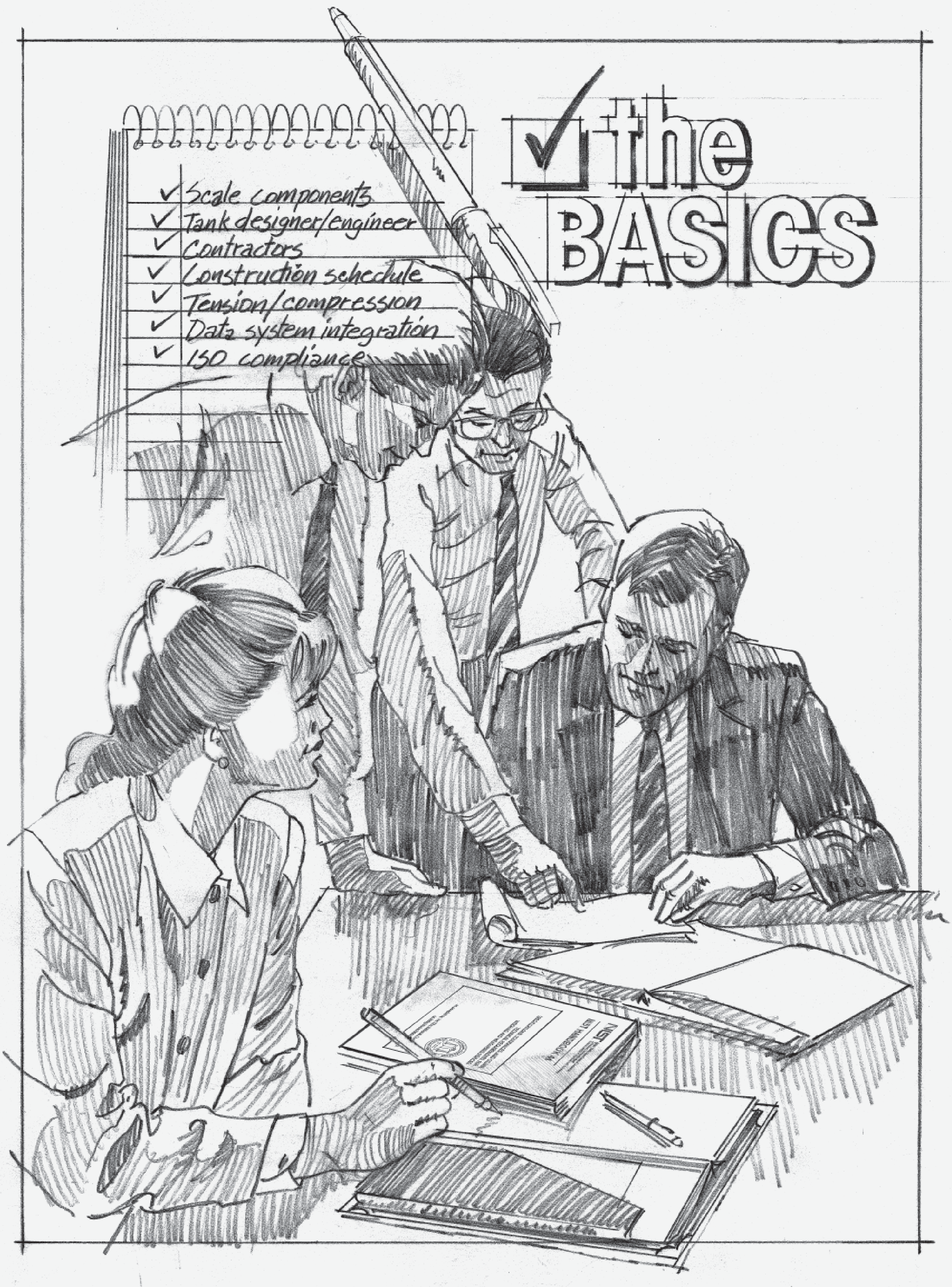
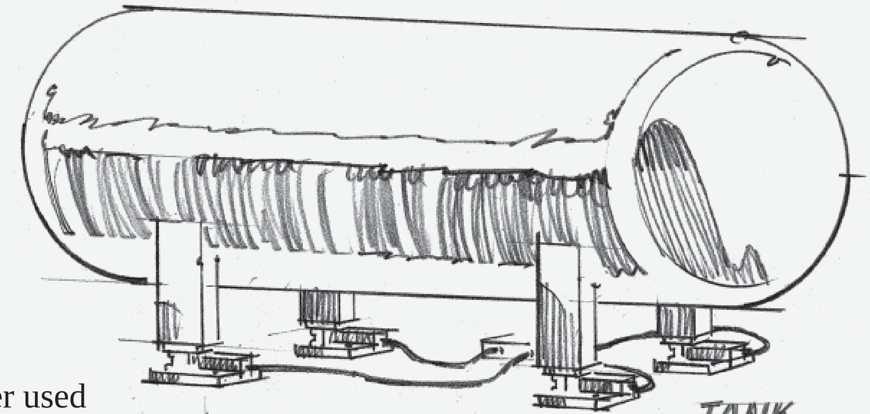

the BASICS
Scale components
Tank designer/engineer
Contractors
Construction schedule
Tension/compression
Data system integration
ISO compliance

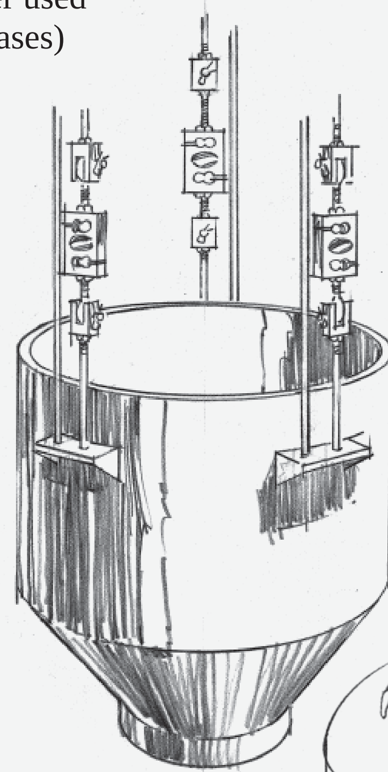
❑ TANKS, HOPPERS, AND VESSELS

We'll be talking about tank scales, but we also mean scales built for hoppers and vessels—basically any fixed container which can be built or retrofitted with load cells so you can get a reasonably accurate and reliable approximation of the weight of the contents.



TANK

A tank is a stationary, closed container used to store liquids (including liquefied gases) or solids in granular or powder form. A tank can be modest in size or very large, holding tens of thousands of pounds. Large tanks tend to be located outside.

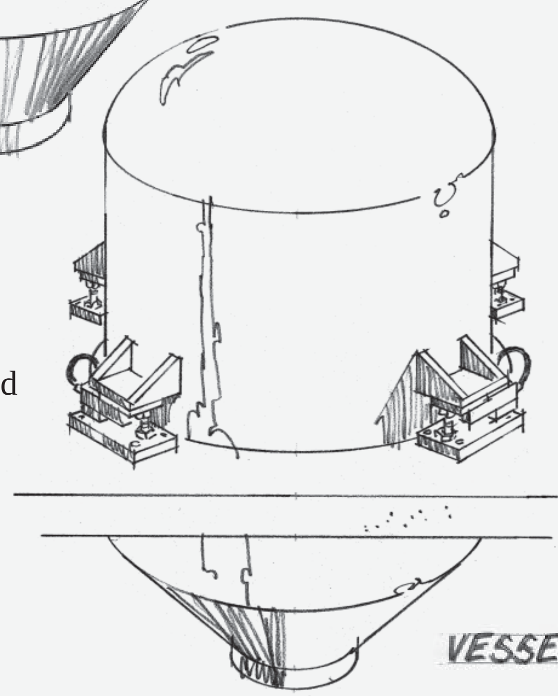


HOPPER

A hopper is a tank with no top. Hoppers are most often used to dispense materials at a steady rate or to accumulate and/or mix a variety of ingredients for subsequent processing. Hoppers tend to be smaller than tanks and are frequently suspended from a superstructure.

A vessel is a sophisticated tank. Vessels may be heated or cooled. Some are insulated, some are not. Some may contain reactions.

In terms of scale technology, the differences between tanks, hoppers, and vessels are of minimal concern. Similarly, it makes little difference if the load cells are added to an existing tank (or hopper or vessel) or if they are included in the original construction. Virtually anything that can be said about tanks will apply to hoppers and vessels. And anything that affects the performance of a built-from-scratch tank scale will also affect a retrofit project.



VESSEL

❑ FLOW METER VS. LOAD CELL TECHNOLOGY

Of all the alternatives to a scale—including sight glasses, floats, a pole marked off in feet and inches, and liquid level sensing devices—the most commonly selected is the flow meter (turbines, magmeters, Coriolis meters, etc.). There are no hard and fast rules for deciding between flow meters and load cells. Both can work well, and both are sometimes used on the same critical or hazardous process as a double check. Neither appears to have an inherent cost advantage, and there are proven work-arounds for most obvious disadvantages.

Nevertheless, we offer, in no particular order, the following thoughts:

■ Load cells tend to be more accurate and longer lived, often for reasons that have no direct relationship to the measuring technology.

■ Flow meters can be used for continuous or batching processes. Load cells must be used for batching.

■ Flow meters lend themselves to the simultaneous addition of ingredients.

■ Flow meters are less sensitive to large disparities in ingredient quantities, e.g., adding a few kilograms of one and several thousand kilograms of another.

■ Load cells work equally well with liquids, slurries, and dry solids. Flow meters work only with liquids and some slurries under some conditions.

■ Load cells are not in contact with the product and are not subject to corrosion by the product.

■ Load cells may prove more adaptable to product or process changes. Flow meters are selected to match specific ingredients and may not work satisfactorily with other materials. They may also be difficult to decontaminate.

■ Flow meters accumulate errors. Load cells do not.

■ You need a separate flow meter for each liquid ingredient. One tank scale usually serves to weigh all ingredients.

❑ YOUR OBJECTIVES

You need to know how much is inside the tank. Somehow, it all seems to come down to value. The more costly the contents of the tank, the more likely you are to need a scale system. For tracking inventory, preventing producer shortages, and controlling quality, weighing is the quickest, most accurate, and most reliable of all your alternatives.

You want to minimize personnel exposure in hazardous areas. With their proven accuracy and low maintenance, tank scales are an ideal choice for measurements in hazardous areas where flammable or toxic materials are handled. Tank scale systems (not just individual components) that meet FM and EXi requirements are readily available.

The same reasoning applies to exterior tanks. The less often you have to send personnel out in bad weather to take a reading or perform a maintenance chore, the lower your risk of a lost-time accident.

You need to pass that information along to other functions. Will your tank scale control filling operations? What about upstream or downstream functions timed to what happens in your tank scale? If your plant is using a computer-controlled manufacturing system, what other functions need specific information? Quality control? Accounting? Purchasing? The computer that logs events and schedules manufacturing? Maintenance?

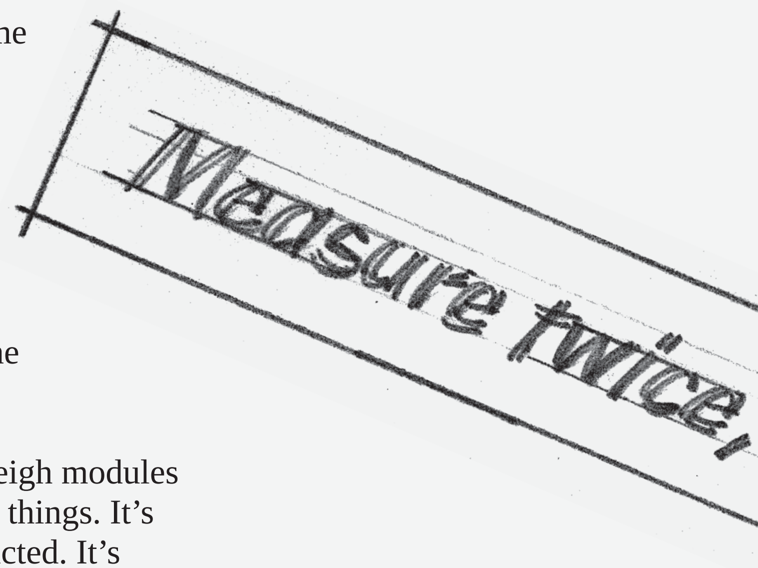
You want maximum uptime. Look for long-term reliability, including the availability of scheduled maintenance by factory-trained technicians. You also want a tank scale that can be fixed as quickly as possible with minimal participation from your own maintenance crews, e.g., disconnecting infeed piping to facilitate load cell replacement.

❑ SOME RULES OF THUMB

Over the decades, we've found six rules of thumb for building tank scales. We learned them the hard way, but they're easy enough to read. Keep them in mind as you go through this booklet and through your own tank scale project. You'll find life will be a lot more productive with far fewer surprises.

1. Select top quality scale components.
All load cells are not created equal. They're all based on the same principle, and most look pretty much alike. But they aren't. We'll show you how to recognize a good one so you can avoid the others.

Weigh modules aren't created equal, either. They're the mechanical suspension systems for load cells. They turn load cells into a weighing system. But, where load cells are confusingly similar in appearance, weigh modules look confusingly dissimilar. In other words, they can be difficult to compare. Nevertheless, a little attention will reveal differences in performance that could be critical. Some can't reliably accommodate predictable forces. Others necessitate extended periods of downtime for repair or replacement.



2. Match the scale components.
The load cells, weigh modules, cabling, junction boxes, signal processors, and scale indicators. It's like a chain, only as strong as its weakest link. The easiest way to match the scale components is to buy them all from the same manufacturer.

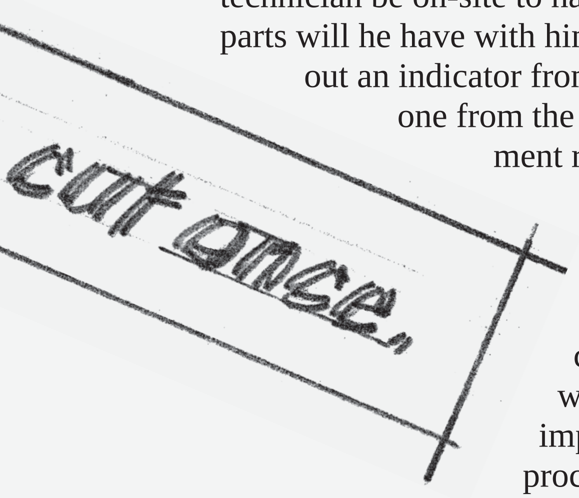
3. It's a system. It's not the load cells or the weigh modules or the indicator or the software. It's all of those things. It's also the tank and how it's designed and constructed. It's also the environment. It's also the piping into and out of the tank. Neglect any one element, and the whole system could be compromised. Accuracy depends on how well the components work together as a unit. Well designed systems are not only predictable and repeatable, they tend to stay that way for longer periods of time with less maintenance.

4. Isolate the tank.
Signals from the load cells can be affected by passing forklifts, nearby pumps and motors, even transmissions from mobile communication units. Such problems can be aggravating and persistent. Most extraneous influences can be minimized if you know what to look for and what questions to ask in the design process. A well isolated tank scale will give more reliable results with fewer problems.

5. If the scale doesn't work right, the fault will probably lie with the design, construction, or installation of the tank.
If the calibration and verification process reveals hidden problems, they probably originate with the tank and its environment. Finding these problems is as much art as science. Experience counts, so get help from somebody who's done this before.

6. Service, especially downtime, could prove crucial to your bottom line. You'll no doubt compare the prices of scale components. Make sure you also compare estimates of service costs over some reasonable period of time like five years. Service and maintenance costs, including downtime for the scale, can be substantial, and they should be addressed during the design phase, not after installation.

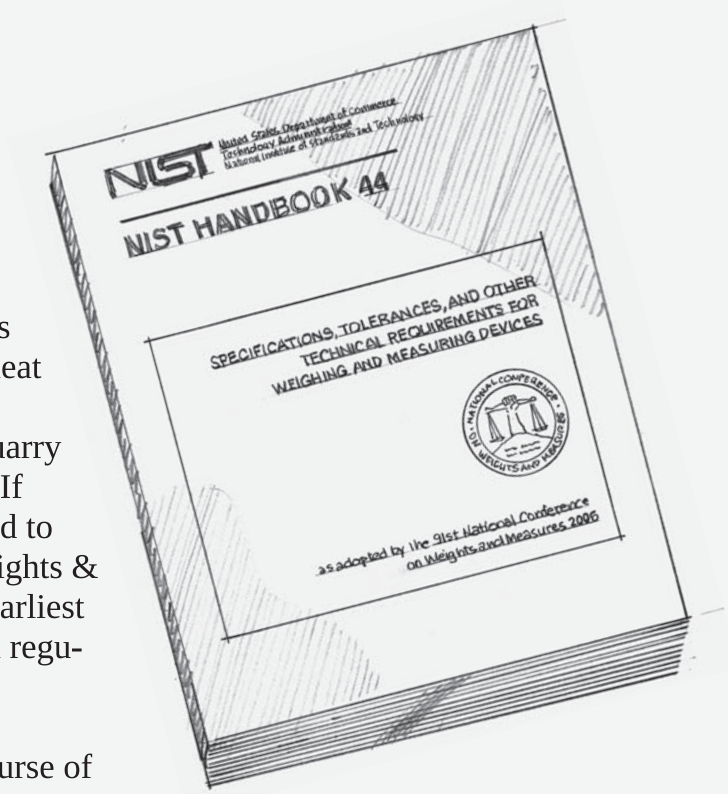
There is plenty to consider here. How long will it take to check your tank scale for accuracy, especially if it's part of an ISO 9000 process? Who will write the procedures and determine the intervals between the tests? How quickly can a service technician be on-site to handle an emergency? What spare parts will he have with him? Can your service supplier swap out an indicator from stock, or does he have to order one from the factory? Does load cell replacement require your tank to be jacked up so high that all the piping has to be disconnected?



This isn't all you should know, of course, but these six rules of thumb will focus your attention on the most important aspects of the scale-building process. The rest we'll cover in some detail throughout the rest of this brochure.

❑ REGULATORY ISSUES

The U.S.



In the U.S., there are two kinds of scales —legal-for-trade and commercial. Almost all tank and hopper scales are commercial.

A legal-for-trade scale is one that determines value or sets the price of the product. The meat scale at the deli counter tells you how much your pastrami will cost. A truck scale at a quarry will determine the price of a load of gravel. If your scale will be legal-for-trade, you'll need to work with state and local (if applicable) Weights & Measures Departments starting at the very earliest stages. Legal-for-trade scales must be tested regularly for accuracy and sealed.

A commercial scale is one you use in the course of conducting your business. You can use it to maintain inventory, measure ingredients, fill packages, and determine postage and shipping costs. Federal, state, and local agencies have no continuing interest in the accuracy of a commercial scale because they assume that you do. We, too, assume you are interested in an accurate scale, so here are a couple of tips that will get you started on the right foot.

Accuracy and performance standards for scales in the U.S. are contained in a publication called *Weighing Equipment Specifications, Tolerances, and Technical Requirements: NIST H-44*. Published by the National Institute of Standards & Technology, it's most often referred to as Handbook 44.

You should also know about NTEP certification. NTEP is an acronym for National Type Evaluation Program, administered by NIST and devised by the National Conference on Weights and Measures. It covers scales and devices used in scales, e.g., load cells and indicators. You'll be building your own, so you won't be buying an NTEP-certified tank scale. But you can buy NTEP-certified load cells and perhaps other NTEP-certified components.

In the U.S., you want NTEP-certified load cells because they are predictable. If a load cell is NTEP-certified, the design has been laboratory tested to the specified standards and a Certificate of Conformance has been issued on it. NTEP certification also means that some states may accept that product design without further testing, a detail that could be important if you are building a legal-for-trade scale. Note that legal-for-trade scales still must be certified and sealed by the appropriate regulatory agency for weights and measures.

International

In the U.S., weights and measures regulations are, for the most part, a state and local concern. In other countries, they are national concerns. So, if you're building a tank scale for export, it has to meet the standards of the destination country. The same holds true for tank scale components.

Many multinational companies prefer, as a matter of policy, to standardize the design of tank scales used in their plants to standards that are acceptable in all of the countries in which they manufacture.

In Canada, those regulations are contained in the CSA standards. There is a great deal of reciprocity between CSA and NTEP, but not in every detail. Check for yourself, especially if your tank scale will be used for legal-for-trade applications.

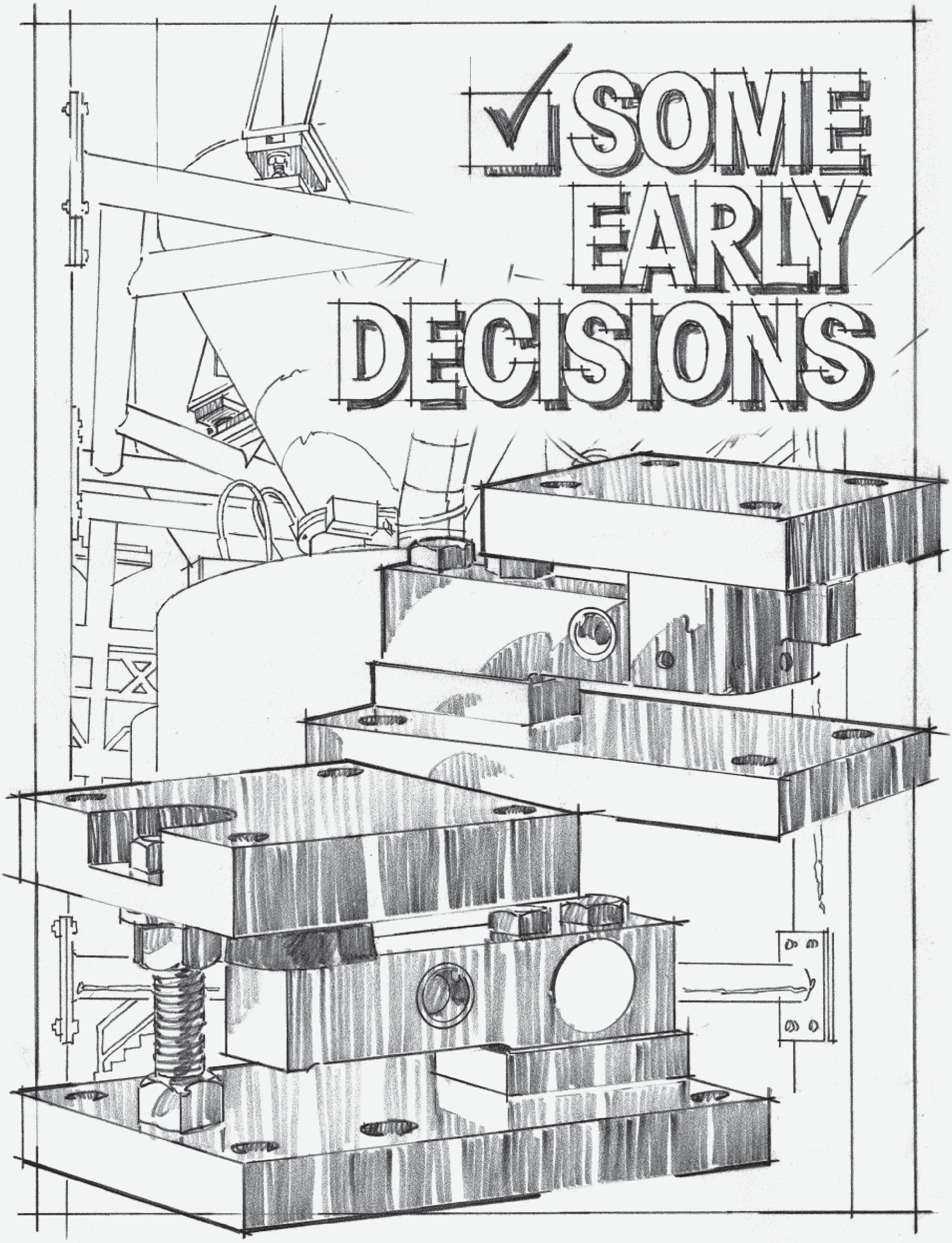
The European Economic Community and many other areas of the world follow the standards of the Organisation Internationale de Métrologie Légale (OIML). The accuracy standards promulgated by OIML are similar to Handbook 44 standards, but more stringent. Other OIML metrology standards, e.g., for creep and temperature ranges, are quite different. Most NTEP load cells do not meet OIML standards. Do not count on reciprocity.

ISO 9001

NATIONAL ACCREDITATION OF CERTIFICATION BODIES

In Europe and increasingly in the U.S. and the Pacific Rim countries, scale components made in plants registered to ISO 9000 standards are becoming an important factor, especially to customers who will use them in processes operating under ISO standards.

Mettler Toledo can supply load cells that meet NTEP, CSA, and OIML standards. All Mettler Toledo load cells, weigh modules, indicators, and terminals are made in plants registered to ISO 9000 standards.


SOME
EARLY
DECISIONS

❑ THE TEAM

You want as much advice and experience as you can find in three areas—design and engineering, a supplier of scale components, and construction. If you have established relationships and a history of success, keep it up. If you want to go shopping or if you're starting from scratch, ask around. Begin with personnel within your company, then talk to your peers at other companies.

Scale vendors like Mettler Toledo can give you the names of engineering firms and construction companies with whom they have worked in the past. Engineering firms can tell you which components they rely on. And don't ignore the importance of experience in construction.

If you work for a large company, you may have experienced in-house engineers to do the design job. They'll have a good idea of which components are compatible, and they will know the performance characteristics of the tank scales they've built in the past. At the same time, all tank scales are different and engineers do get transferred to other departments. You should understand how tank scales work and know what questions to ask.

Many companies, even large ones that could support in-house expertise, give tank scale jobs to system integrators. These companies specialize in the design of tank scales and draw on the accumulated experience gained with dozens of clients. Some integrators do only the design and specification work. Most offer additional services, all the way through turnkey contracts.

The most time-consuming approach is to work separately with each entity. You'd work with the engineer on the design and specifications, including the evaluation of suppliers and their products. Do your own purchasing. And identify, negotiate with, and supervise a contractor to do the installation.

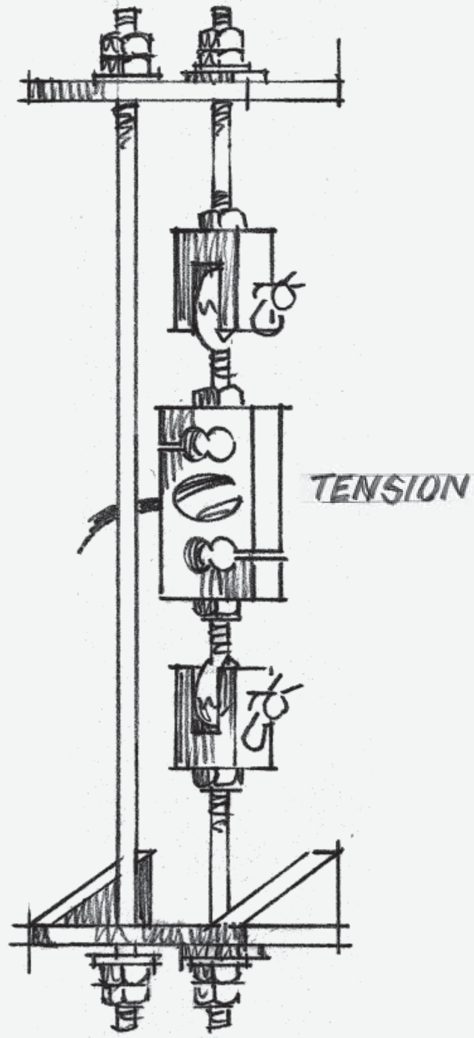
Which approach is best? That depends—on the size of the project, the budget, the time frame, the importance of the scale, established relationships with trusted suppliers, and any number of other factors. There may be a best way for you at this time, but there's no one way.

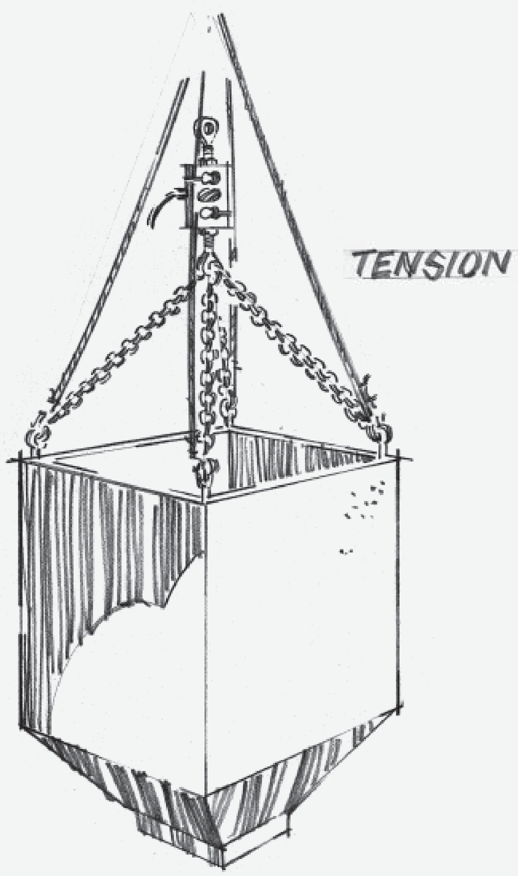
❑ TENSION VS. COMPRESSION

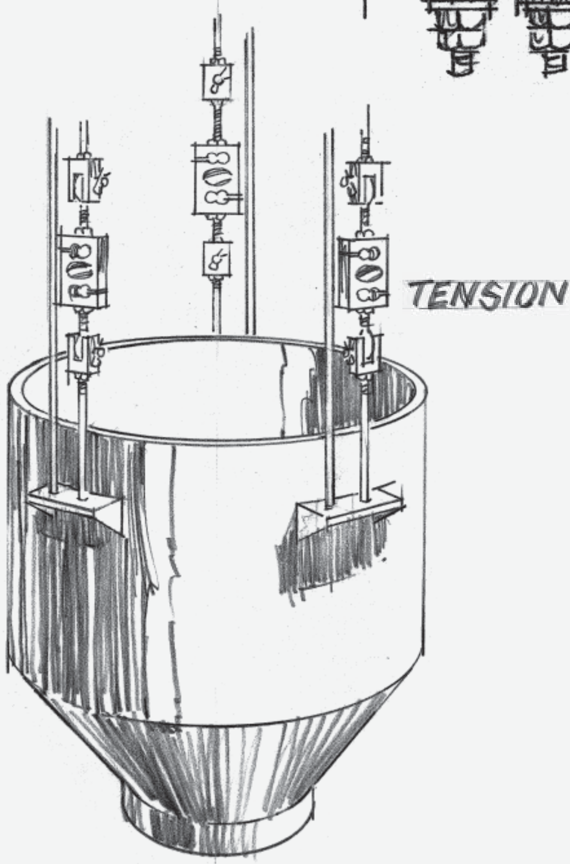
Probably the most basic decision—and one of the easiest—is whether the tank will sit on top of three or four compression load cells, one for each leg, or be suspended from one or more tension load cells.

If the tank is outside, a compression design will probably be better. You won't need a superstructure from which to suspend the tank. You shouldn't have to build a restraint system to accommodate wind loads. And you can build a larger tank because compression load cells are available in much higher capacities, allowing higher gross weights.

Inside, it's a different story. Tanks and hoppers are generally smaller, a superstructure already exists, and you don't have to worry about wind loads. Both types of tank scales can be built to acceptable levels of accuracy. Both will probably cost about the same. And both must be reasonably well isolated from the movement and vibration of the building.





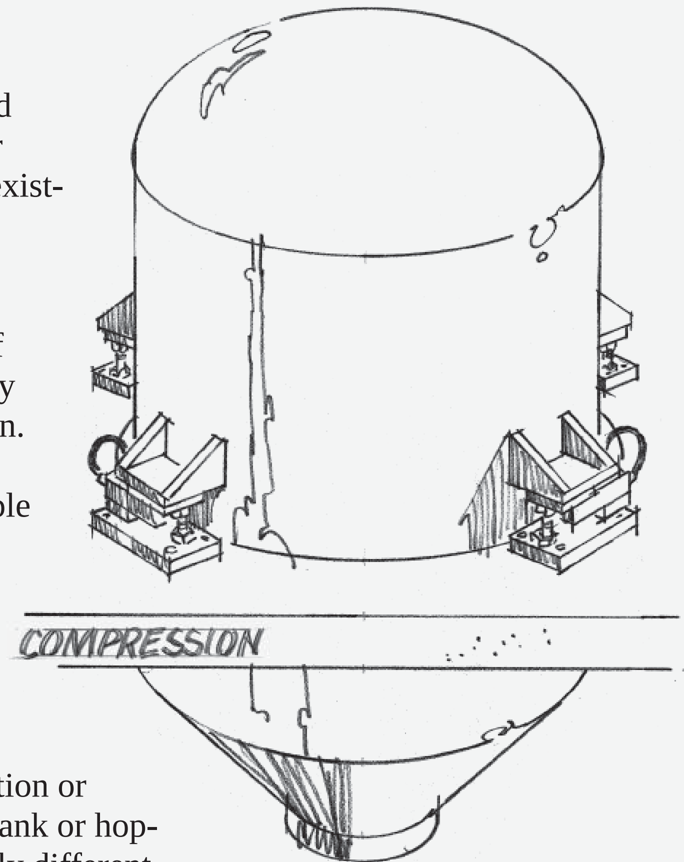


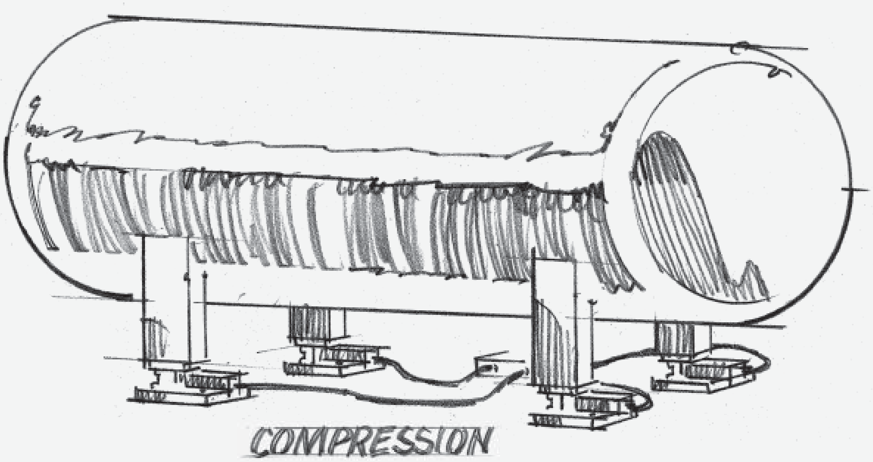
The determining factors will probably be:

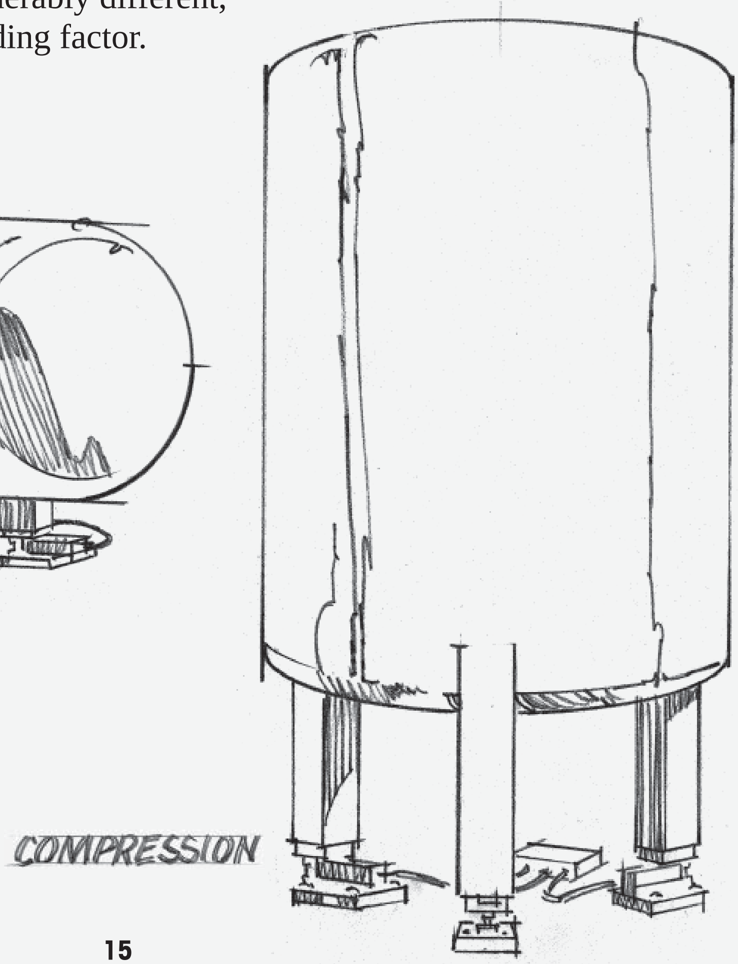
- **Floor space.** A hanging tank suspended from tension load cells takes up zero floor space. That's often preferable to moving existing equipment or re-routing forklifts.

- **The process.** If the tank must go in a specific location because of the process of which it's a part, the location will probably determine the tank's size and configuration. On the other hand, if the tank supplies an easily transportable liquid or gas to multiple work stations, there may be several adequate locations, and either configuration would work.

- **The structure.** The tank or hopper must be as isolated as possible, and that often means a separate supporting foundation or structure. The cost of the structures for a tank or hopper in a given location may be considerably different, and that difference could be the deciding factor.



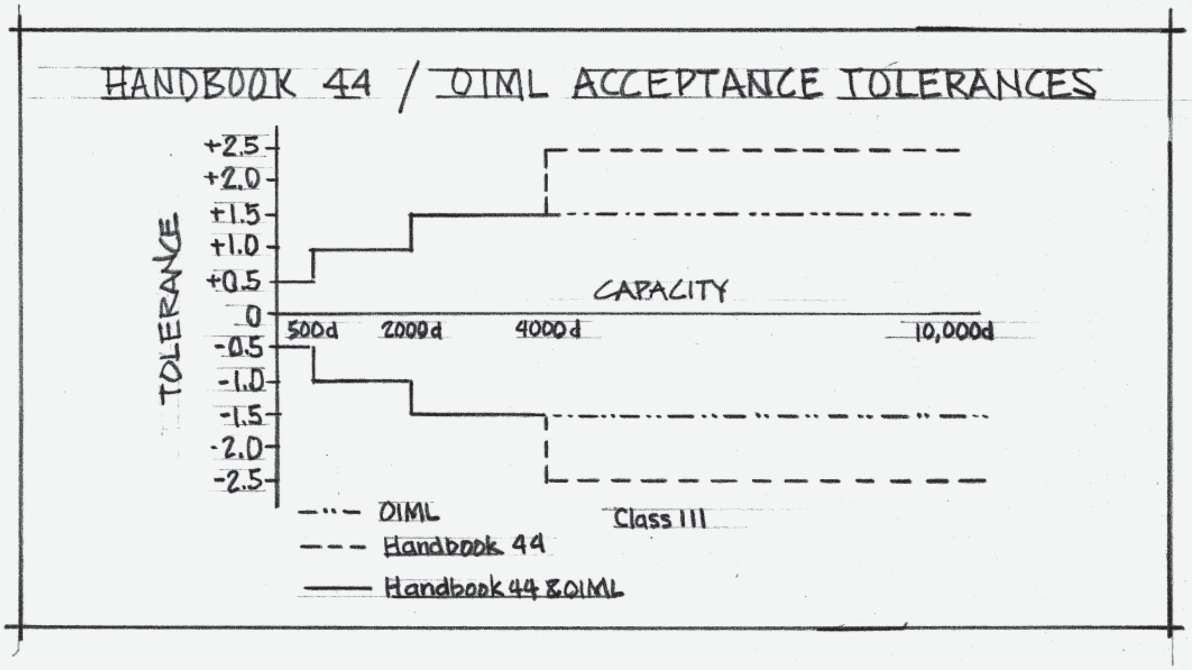




❑ RESOLUTION, PRECISION, REPEATABILITY, AND ACCURACY

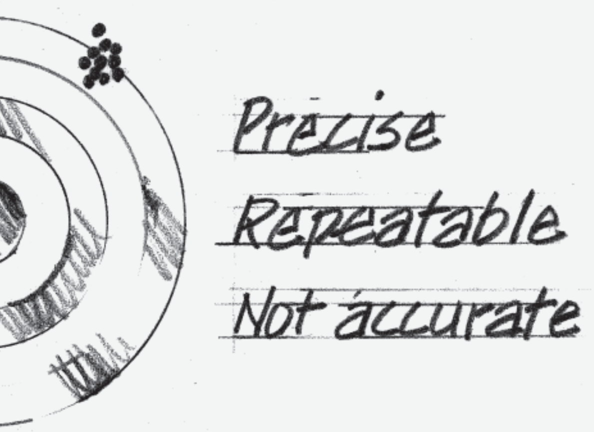
There are any number of definitions of resolution, precision, repeatability, and accuracy. Here's what we mean by those terms.

Resolution is the smallest increment of weight change that can be displayed by the indicator. It is an electronic characteristic based on the capabilities of the load cell and related instrumentation. Resolution is related to, among other things, signal strength and stability and the design of the electronics. There is no correlation between resolution and accuracy.



Precision means the tank scale will show very nearly the same result each time a given volume of product is weighed. The results won't always be the same, but we want a very tight grouping. Precision means **repeatability**, and that is often the most important characteristic of a tank scale used for batching and filling. Precision is affected by the structure of the tank scale—infeed and outfeed connections, integral mixers and vibrators—and its environment—thermal cycling, wind and snow loading, and extraneous vibrations. A scale can be precise and yield repeatable results without being accurate.

Accuracy means that the reading on the tank scale indicator is in fact very close to the actual weight of the contents as compared to a traceable, certified weight standard. If a scale is accurate, it is also precise. Accuracy can be adversely affected—often to a much larger degree—by the same things that affect repeatability.



❑ HAZARDOUS AREAS

Siting your tank scale in an area that has a high risk of fire or explosion calls for some advance planning. Check the applicable building codes and your insurance underwriter. One solution is to use explosion proof enclosures and intrinsically safe, low-voltage components that will not overheat or spark.

Another solution is to place the electronics in a separate, safe area and place an electronic barrier between the electronics and the scale itself. Regardless of the solution, the entire system, not just the components, will likely have to meet Factory Mutual (FM) and/or ATEX directive (Exi) specifications.

❑ SIZING THE LOAD CELL

There are three primary determinants to sizing load cells—the weight of the empty tank, the weight of the contents (product), and the number of load cells, i.e., the number of supports or legs on the tank. In addition, environmental factors such as expected windloads (see page 43) and possible seismic activity (see page 41) have to be accommodated. For example—

The engineer tells you that the tank needed to hold 20,000 lb of liquid will weigh 10,000 lb. That's 30,000 lb to be multiplied by a safety factor of say 1.25 to account for unequal load distribution or any underestimation. The total is 37,500 lb. The tank will sit on four legs, so four load cells each with a capacity of 10,000 lb will do the job. But—

20,000 lb liquid
+ 10,000 lb tank wt.
30,000 lb total wt.
x 1.25 safety factor
37,500 lb ÷ 4 legs = 9,725 lb per leg
∴ 10,000 lb capacity load cell per leg.

Calculations show that the design of the tank and the maximum winds normal for your part of the country could subject any of the four load cells to significant downward forces when the tank is full. Those same winds could also lift the empty tank, subjecting the load cells to uplift forces (see page 43 for a discussion of uplift forces).

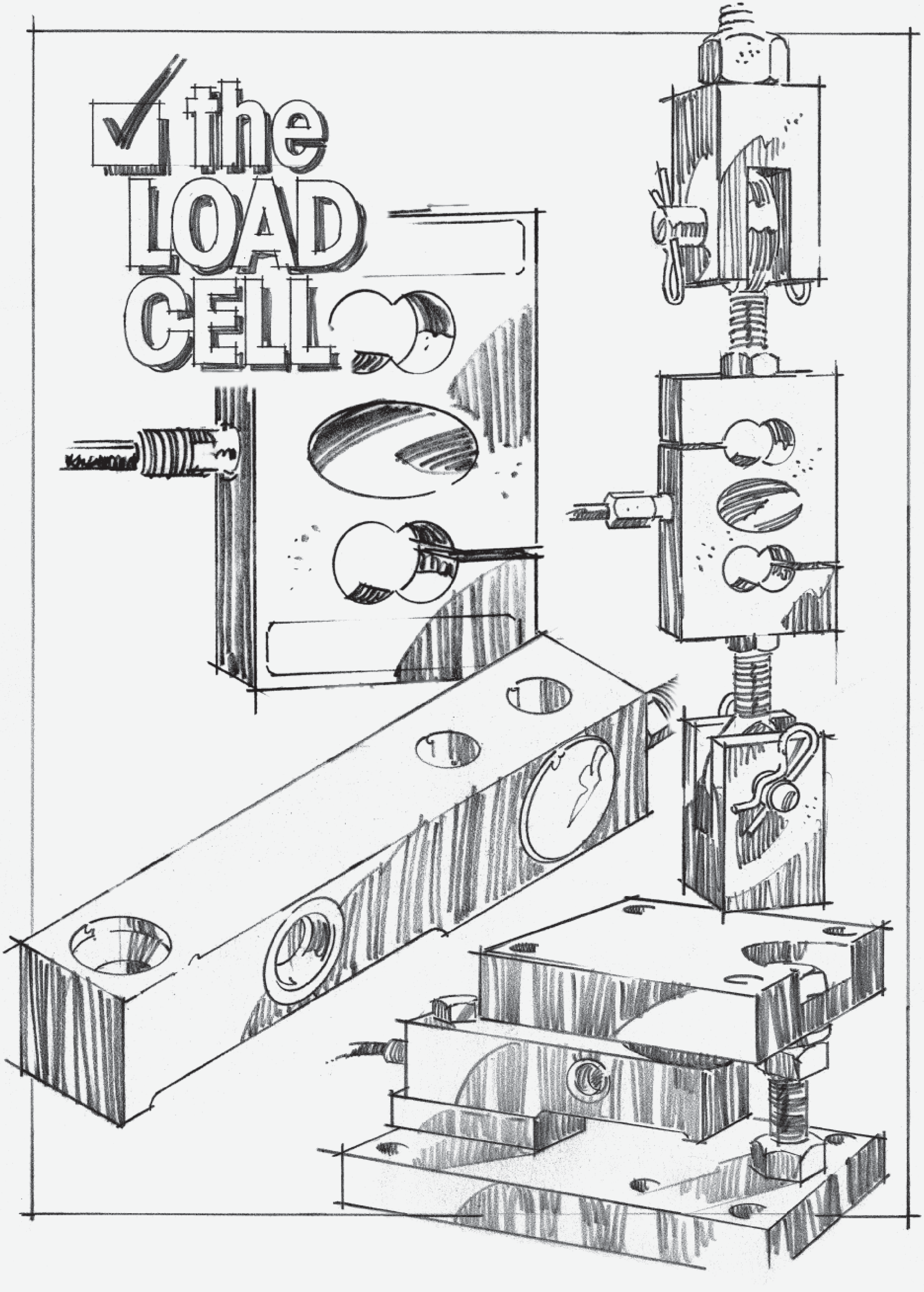
Similarly, calculations may have to be made for a possible earthquake. The greater of the two forces…windload or seismic…could influence the size of the load cells.

Let’s assume that the seismic potential in this example is relatively low, and the windload forces are greater. We’ll therefore size the load cells for the tank, its contents and the windload. In addition, the weigh modules must be able to resist the wind uplift forces, or a system of stay rods will have to be designed to do the job.

If the resolution of the load cells–sized to accommodate all predictable forces–meets your requirements, then you’ve got a tank scale design. If it doesn’t, your engineer has to try another approach.

Perhaps shielding the tank from wind will allow you to reduce the size of the load cells. Or maybe you need a new approach—two tanks that are half the size of what you originally thought you needed—or maybe a big tank for inventory storage in conjunction with a smaller tank for accurately dispensing its contents.

Remember, all external forces acting on a tank must be considered in order to ensure a safe and reliable installation. You cannot compromise structural integrity to gain resolution or performance.


the
LOAD
CELL

Your hopper will be weighed by a tension load cell incorporated into the suspending cable or rod. Tension load cells are sometimes called S load cells because of their shape.

Your tank will sit on a compression load cell. There are two kinds, beam and column.

A beam-type compression load cell is a steel bar 4" to 12" long. Nickel-plated carbon steel is common, but stainless steel is used with increasing frequency because of its better corrosion resistance. A beam load cell is used horizontally and may be supported at one or both ends. If it’s supported at one end, the weight of the tank sits on the other end. If it’s supported at both ends, the weight of the tank sits in the center.

A column load cell sits vertically and generally has a canister around it enclosing the electronics.

A tension load cell is incorporated into the suspending cable or rod. The weight of the tank distorts the S-shape—the greater the weight, the greater the distortion.

All load cells distort when a load is placed on them. S-shaped tension load cells tend to straighten. Beam load cells deflect. Column load cells grow thicker.

The amount of distortion is measured by electronic strain gages (wheatstone bridges, if you remember your high school physics). The strain gages are glued to the load cell. As the shape of the load cell changes, so do the shapes of the strain gages. This alters an excitation voltage, typically 10 volts DC, existing across the strain gages. The resulting change in voltage, measured in millivolts, is proportional to the applied load. The summed average of the electrical signals from all the load cells yields the total weight of the tank or hopper and its contents.

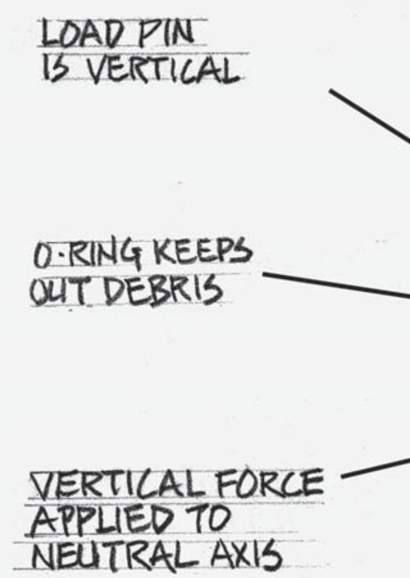
The possibility of getting a defective load cell is exceptionally low, but some load cells will last longer and provide more consistent and reliable results. Here's what you should look for.

❑ A WELL-DESIGNED COMPRESSION BEAM LOAD CELL

1. The load rests on the neutral axis. The neutral axis is the equivalent of the sweet spot on your tennis racket or your favorite driver. The sweet spot of a load cell is inside, so the load must be applied at the bottom of a blind hole drilled from the top. If the force is applied via a threaded load pin, the load will be supported by the threads at the top of the hole, thus missing the sweet spot.

The hole also prevents the load point from shifting back and forth along the beam (affecting the amount of deflection) or from side to side (twisting the beam).

If the load rests on the neutral axis, the readings from the load cell will be linear and predictable up and down its weight range. This makes calibration and verification of the finished tank scale much simpler.



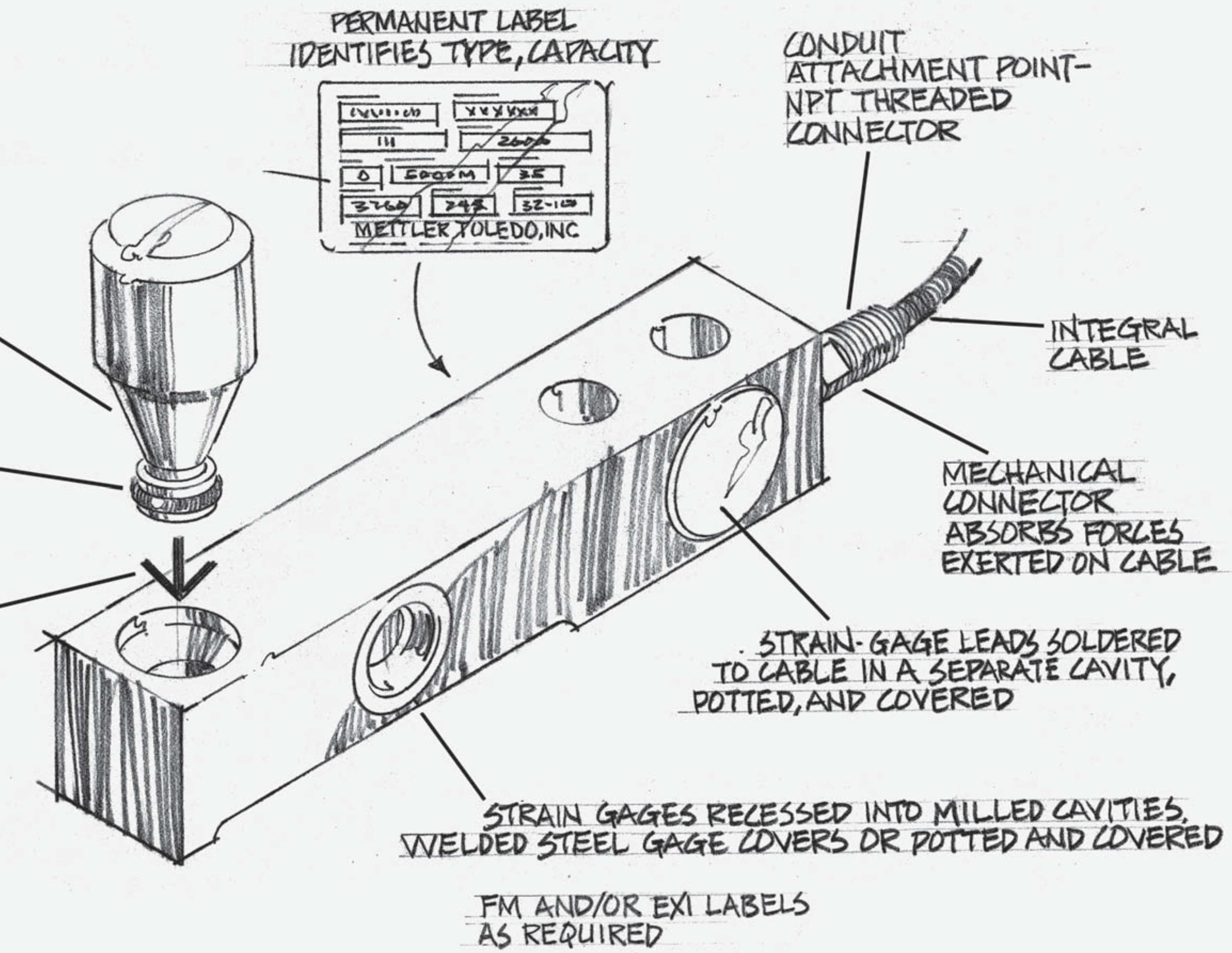
2. The strain gages are within the outline of the load cell and well protected. Strain gages are quite delicate and must be protected from mechanical damage and corrosion. Mechanical damage can be caused by vibration, dropped equipment, and misplaced hammer blows. Corrosion is most commonly caused by water wicking through or around the insulation on leads.

The strain gages should be located within cavities milled into the load cell. Strain gages attached to the outside of a load cell and covered by a boot or shroud are not adequately protected. Ideally, the strain gage cavities should be covered by steel caps welded to the load cell body. At a minimum, the cavities should be potted, i.e., filled with a waterproof resin, and covered with a metal cap.

The leads from the strain gages should run through the interior of the load cell to another milled cavity where they are soldered to the cabling. This cavity, too, should be potted and covered. A load cell with a cable emerging directly from the potting will be susceptible to damage by any substantial pull on it and also from corrosion due to wicking.

3. Cabling is substantial and mechanically attached to the load cell. The cable should exit the load cell via a sturdy mechanical connector which can resist any pulling or twisting forces on the cable. Spring clips or screw-tightened clips holding the cable to the load cell are not reliable. If there's a boot, its sole purpose should be to prevent debris from building up.

The cable is an integral part of the load cell. Its length and electrical characteristics, including those of any internal connections, all affect the load-cell signal. When a load cell is factory tested, the results include the effects of the cable. If a cable is damaged, a new load cell with a new cable is needed. Cables should not be spliced or replaced in the field.



❑ A WELL-DESIGNED TENSION LOAD CELL

Tension load cells are simpler than compression load cells for two reasons. First, there is no need to compensate for thermal expansion and contraction. Second, they're high and away from stumbling feet, dropped tools, dumped loads, and accumulations of debris. Nevertheless, there are four things to look for:

1. The load will always be vertical. The combination of the load cell and the mounting hardware should approximate a universal joint so that the load is always vertical.

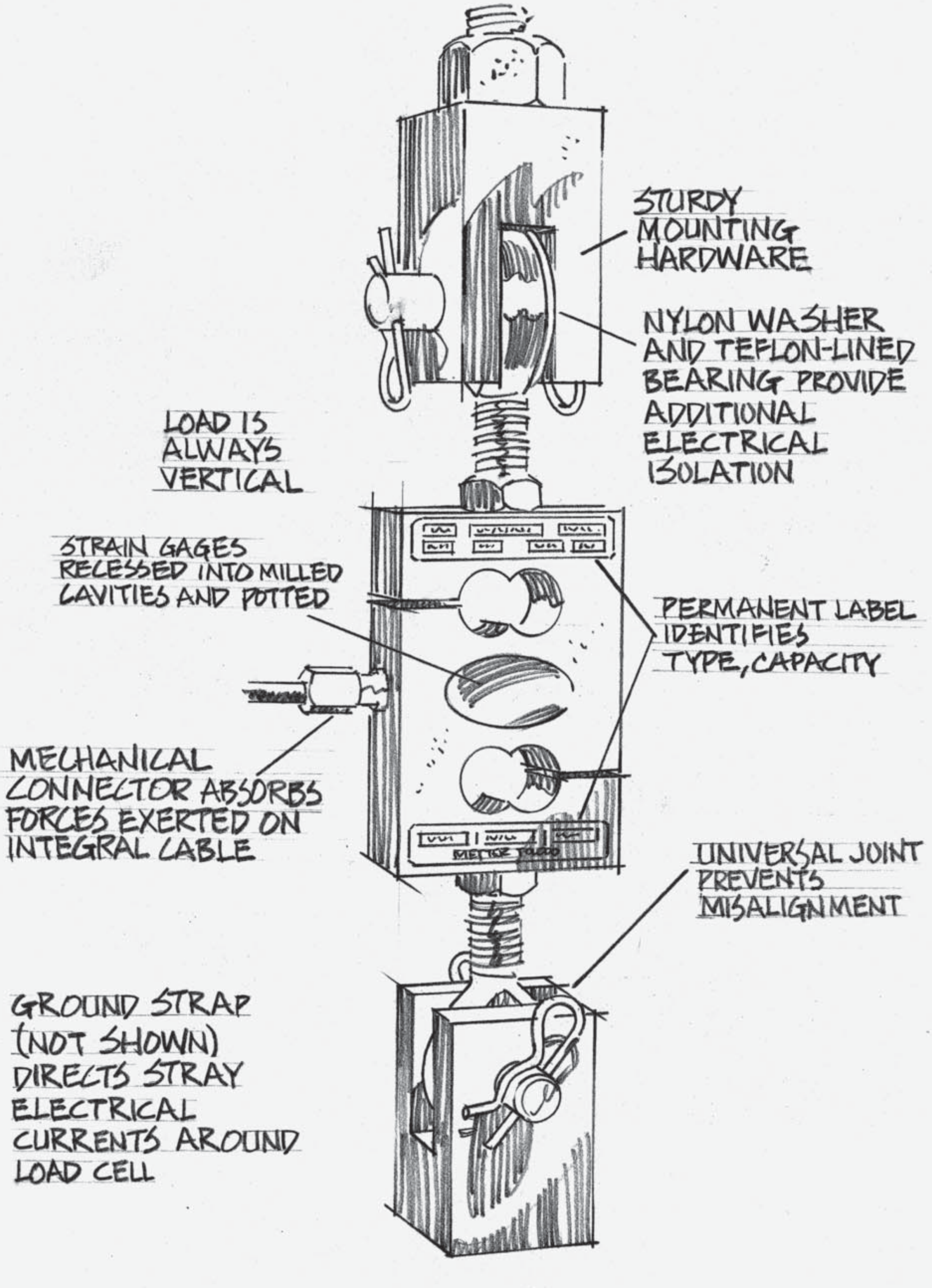
2. The strain gages are within the outline of the load cell and well protected. A tension load cell may be high and away, but it still makes good sense to protect the strain gages from mechanical damage…something could fall against it…and moisture. Look for a clean profile and epoxy potting.

3. Integral cable is substantial and mechanically attached to the load cell. It should be a cable that emerges from the load cell, not a twisted pair. And the cable should be securely anchored in a mechanical connector.

4. A grounding strap should be used to direct stray electrical currents around the load cell. In addition, teflon-lined rod end bearings and nylon insulating washers are recommended.

❑ SAFETY RODS AND BUMPERS

A tank scale suspended from a tension load cell needs safety supports in case of a failure of the suspension system. This usually takes the form of three or more rods that extend down from a structure that can reliably support the weight of the filled tank, plus an appropriate margin of safety. The rods pass through over-sized holes in brackets attached to the circumference of the tank. Nuts or other restraints above and below the brackets will take the load in case of failure. Bumpers around the perimeter may be needed to prevent swaying.


STURDY MOUNTING HARDWARE
NYLON WASHER AND TEFLON-LINED BEARING PROVIDE ADDITIONAL ELECTRICAL ISOLATION
LOAD IS ALWAYS VERTICAL
STRAIN GAGES RECESSED INTO MILLED CAVITIES AND POTTED
PERMANENT LABEL IDENTIFIES TYPE, CAPACITY
MECHANICAL CONNECTOR ABSORBS FORCES EXERTED ON INTEGRAL CABLE
UNIVERSAL JOINT PREVENTS MISALIGNMENT
GROUND STRAP (NOT SHOWN) DIRECTS STRAY ELECTRICAL CURRENTS AROUND LOAD CELL

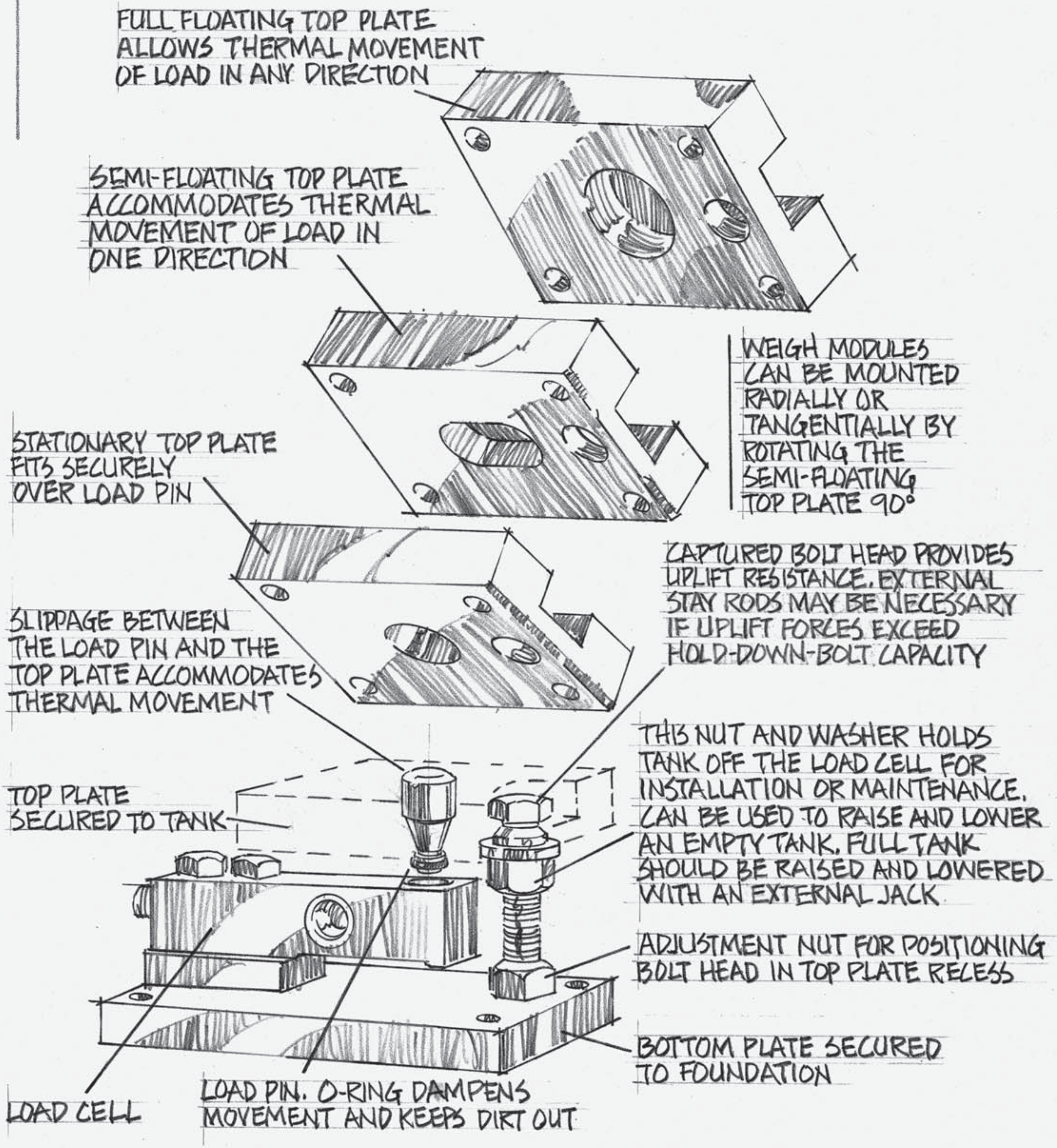
the WEIGH MODULE

To install a tension load cell, all you have to do is attach the connecting rods.

Compression load cells, on the other hand, must first be incorporated into a weigh module in order to be usable. This is done at the factory by your scale system supplier, so the load cell may not even be noticed. In fact, most people use the term load cell to refer to the weigh module.

The weigh module is the suspension system for your tank scale. It directs the weight of the tank onto the load cell. But a weigh module must also accommodate other forces, e.g., wind loads, seismic activity, and thermal expansion and contraction of the tank; this is where most weigh modules are deficient.

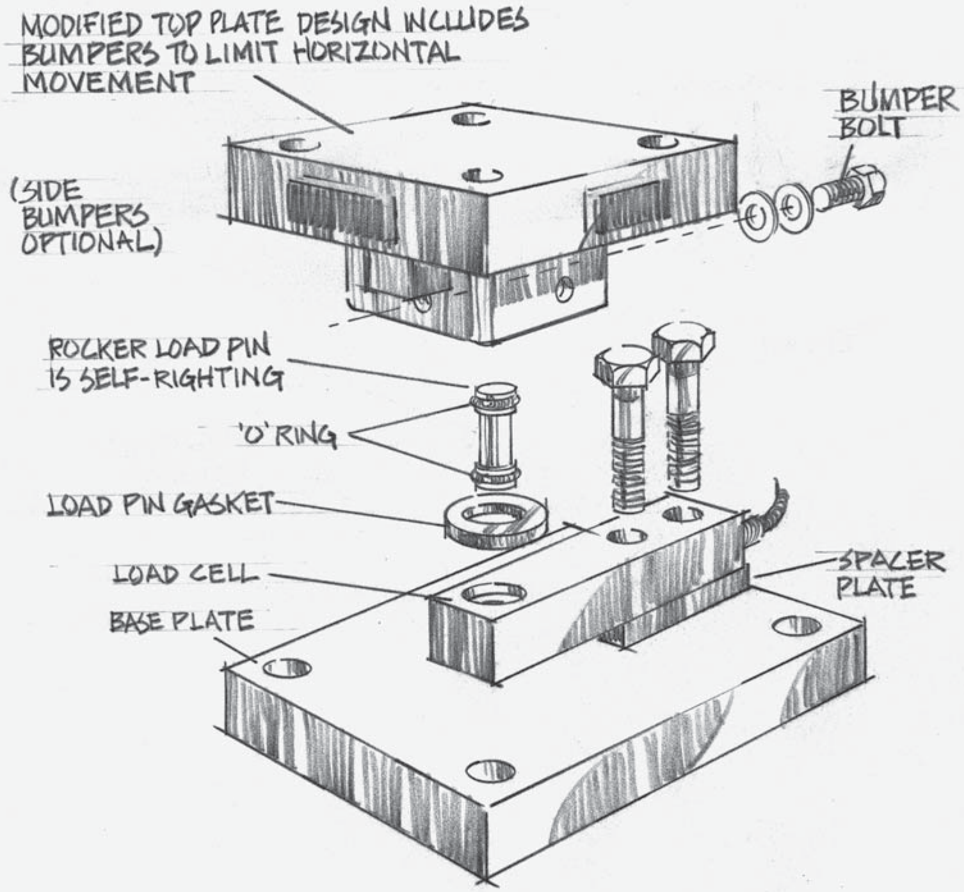
The easiest way to show you what we mean is by showing you a detailed drawing (opposite) of a sliding-suspension weigh module and what it is designed to do. Then we’ll show you some other general designs and point out the differences.



WEIGH MODULE WITH SLIDING SUSPENSION

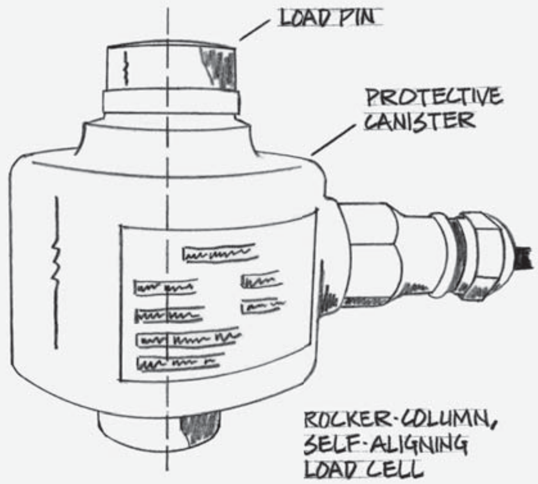
❑ SELF-ALIGNING WEIGH MODULE

In applications where high horizontal forces can be expected, Mettler Toledo's self-aligning weigh module may be a better choice than the sliding-suspension weigh module. Such applications may include structures with high horizontal shock forces, e.g., an indexing conveyor or a tank with horizontal infeeds in which the motion of the in-rushing product is stopped by the opposite tank wall. Other applications include conversions of mechanical floor scales intended to accommodate vehicles such as forklifts that will be braking and accelerating, and conveyor sections used to weigh heavy bags, rolls of paper, or drums in motion.



Mettler Toledo's self-aligning weigh modules accommodate high horizontal forces.

The primary difference between the self-aligning weigh module and the sliding-suspension weigh module is the load pin. Instead of remaining perpendicular to the load cell, the load pin in the self-aligning weigh module is allowed to rock when subjected to horizontal forces. Once the load on the scale stabilizes, the load pin returns to a vertical position to yield an accurate weighment.

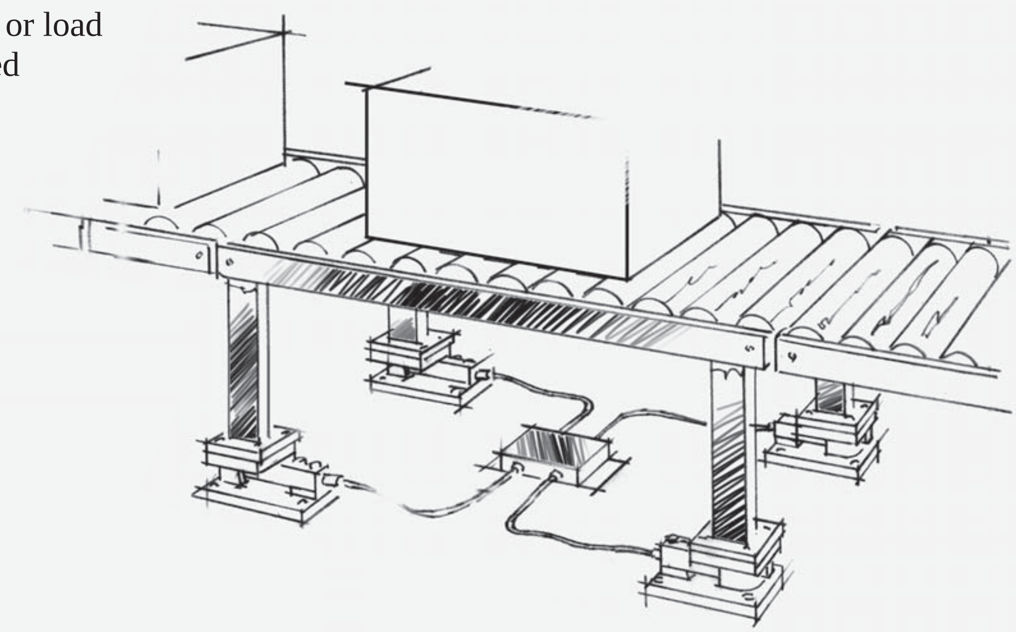


Some self-aligning weigh modules use a load cell with a built-in rocker load pin. In essence, the load cell is a large columnar pin with spherical radii at each end. The sensitive strain gages and circuitry are covered by a metal canister welded to the column at both ends.

The horizontal movement of the scale or weighbridge is limited by fixed or adjustable bumpers built into the weigh module support plates. During installation, alignment tools are used to make sure the load cell, rocker pin, and top plate are registered (aligned) in the correct relative positions. After the weigh module mounting plates are secured to the tank and foundation, the alignment tools are disengaged.

Accuracy Tip

Of all available designs, self-aligning weigh modules provide the highest degree of precision and repeatability because of their self-righting load pins or load cells and registered mounting.



❑ OTHER WEIGH MODULE DESIGNS

The differences in weigh module designs are most noticeable in three areas:

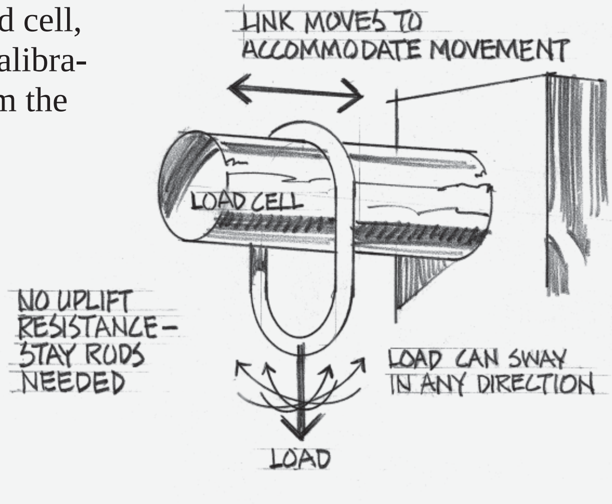
1. Thermal movement. The manner in which the weigh module accommodates the expansion and contraction of the tank. The idea is to keep the force (weight of the tank) straight down onto the same point of the load cell at all times. Some designs accommodate movement by allowing the force to vary from vertical and/or allow the point of application to move. This alters the indicated weight, but you don't know the magnitude of the change.

2. Resistance to uplift and tipping. Some modules have no resistance to uplift forces induced by wind loads or seismic activity. For all of these tanks, a system of stay and check rods will be required, adding to the expense of design and construction. Note that some applications require such a high margin of safety that any tank employing any weigh module will need stay rods.

3. Maintenance. Replacing a load cell (it does happen) should be relatively quick and easy, but not with some weigh module designs. They require the tank to be raised one to several inches which, in turn, usually requires that all of the piping into and out of the tank be disconnected. A half-day, two-man job thus becomes a two-day, four-man job…not to mention the lost production time and heavy equipment rental.

Link Supported Design

In this design, the weight of the tank is suspended from the load cell by one or more links. The unsecured link accommodates thermal movement, but may move out of vertical, affecting the scale's accuracy. Bumpers may be needed to prevent swaying. For safety, a secondary support system is required. This design is generally used only in areas protected from wind and weather. Lastly, changing load cells can be difficult and time-consuming. One variation uses a yoke to which the tank can be attached. It has the same problem, i.e., it accommodates thermal movement by allowing the applied load to move along the load cell, changing the load application point and affecting calibration. It affords uplift resistance, but that comes from the load cell itself, a poor design feature.

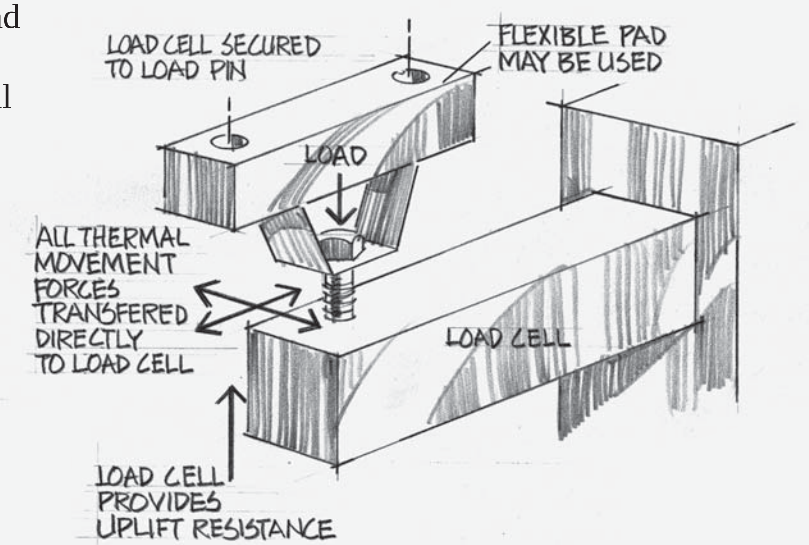


LINK SUPPORT

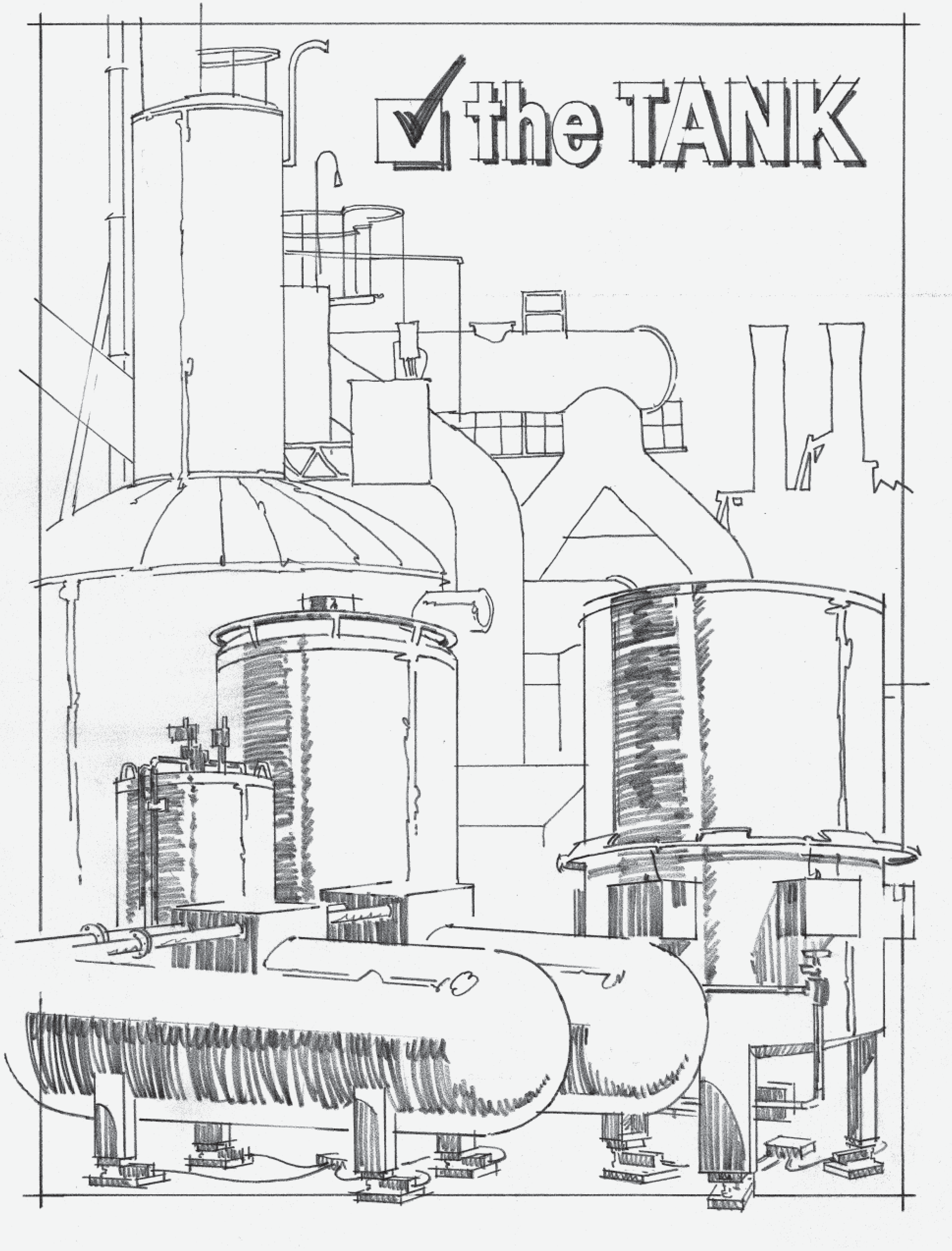
For the deficiencies discussed here, there is no real difference between a cantilevered load cell secured at one end with the load applied at the other end…or a load cell secured at both ends with the load applied in the center.

Rigid Load Design

In some rigid or fixed load designs, the load pin is bolted vertically into the load cell. If the tank support is secured to the pin, then there is no accommodation for thermal movement. Even worse, the applied load can induce twisting or racking movement in the load cell, further modifying the signal and the indicated weight. Moreover, uplift resistance is supplied by the load cell. Other designs employ flexible mounting pads between the tank support and the load cell, allowing a minimal amount of movement. The lateral forces are still there, even if in reduced strength.



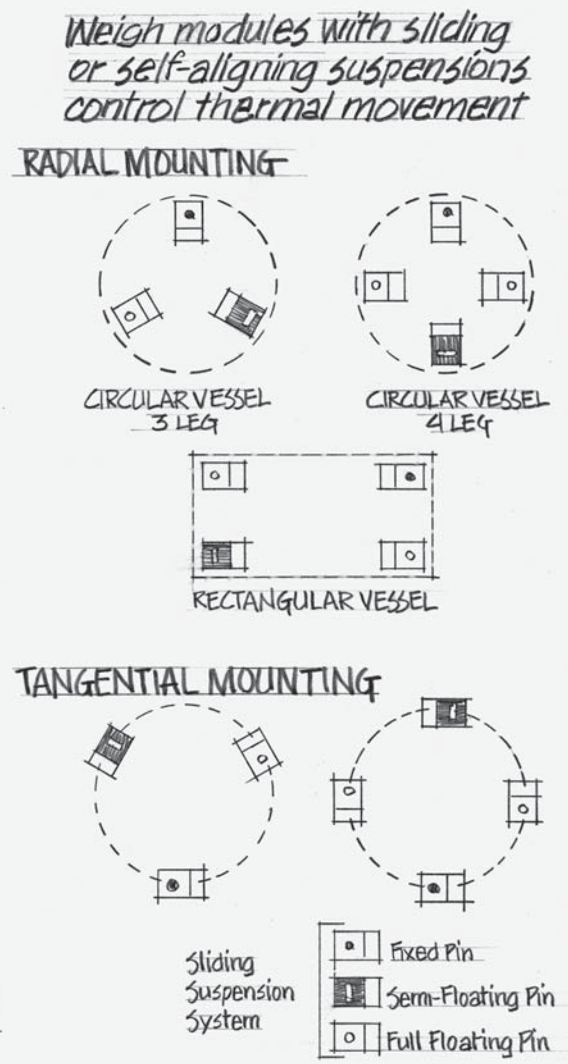
VERTICAL RIGID PIN


the TANK

The design and construction of the tank should command the bulk of your time. The manufacturer of the load cells and the weigh modules you select will have done all the engineering for those components. For the tank, though, the engineering must be done all over again from scratch. You can minimize the engineering job by (1) using a proven design, preferably one that is working in your own plant and (2) using a design engineer who's done tank scales before and done them successfully. The same holds true for installation. Pick a contractor who's done it before and done it well. Here are some of the things you'll need to pay attention to.

❑ FULL OR PARTIAL MOUNTING

Most tanks are fully mounted, i.e., there is a load cell under each leg. Partial mounting, where there is a load cell under one of three legs or load cells under two of the four legs is an alternative. It can save you money, but only if two conditions are met. First, the tank contents will be liquid so the center of gravity always falls along the same vertical line. Second, you can live with an accuracy of > 0.50%.



❑ THERMAL MOVEMENT

Thermal movement is typically not a problem for a suspended hopper. It is, however, a serious concern for tanks placed on compression load cells. The same problem exists for weigh modules placed under legs and for weigh modules placed under brackets extending from the sides of the tank.

Tanks are going to expand and contract with temperature changes. The movement will vary, depending on the circumference of the tank, the material used to construct the tank, and the temperature range. Heated or cooled tanks and horizontal tanks located outdoors deserve extra attention. It takes very little movement to move the load on the load cells out of vertical and produce erroneous weighments.

The sliding-suspension weigh module accommodates thermal movement by allowing the top plate to move in relation to the load pin (see illustration, page 27). The load pin is always vertical.

Note that sliding-suspension weigh modules can be positioned radially or tangentially. Each tank requires a fixed-pin weigh module and a combination of semi-floating and full-floating weigh modules. The top plate of the semi-floating weigh module is rotated 90° to accommodate tangential mounting.

❑ PROVISION FOR ADDING WEIGHTS

If you're going to calibrate and verify your tank scale using known test weights, you'll need mounting lugs evenly spaced around the tank from which to hang them. See Calibration & Verification section, page 51.

If you can get by with electronic calibration, there will be no need for lugs. Keep in mind, though, that adding lugs to a finished tank can be time consuming and expensive.

❑ THE FOUNDATION

The foundation surfaces on which the weigh modules sit must be level, rigid, and all in the same plane. The foundation must also be designed to transmit little or no vibration from nearby machinery or vehicle traffic.

Concrete or steel, a good foundation means that all the weigh modules (and hence the load cells) will be level and in the same plane. Each will support a relatively equal share of the total load, and the individual loads will be vertical. Minor surface variations can be corrected during installation by shimming the weigh modules to within ± 0.5° of level.

Load cells normally bend only 0.01-0.03" under normal rated loads, so they are sensitive to any structural deflection.

The foundation must be rigid so the weigh modules (and the load cells) remain level throughout the weight range of the tank scale. If the weigh modules deflect as the tank is filled, the load on the load cells will no longer be vertical, but angular. This introduces non-linear errors and imprecise weighments. For steel supporting structures, loads should be centered over the webs of the I-beams. Welded gussets may have to be added to prevent the beams from twisting or the flanges from bending.

Multiple tanks may be installed on a common foundation, but take care to isolate the tanks themselves. The movement of one tank must not affect any other tank.

Any tank supported from an upper floor or mezzanine requires special consideration by the design engineer. He has to make sure that the floor won't deflect excessively under load (no more than $\frac{1}{2}$"). This may require reinforcement of the floor or the construction of a separate foundation independent of the building structure.

Vibrations transmitted through the foundation and supporting structure will be converted by the strain gages in the load cells into electronic signals, i.e., noise. Keep in mind that it doesn't take much to scramble a signal that is read in microvolts. Some signal noise due to vibration can be electronically filtered out, but the surest approach is to isolate the tank from extraneous vibration in the first place. Solutions may range from independent foundations and supporting structures to cushioning pads under the tank legs.

❑ VIBRATION AND NOISE

Even with an independent foundation, vibration may be inherent in your tank design. Vibration can be induced, for example, by the motor of a mixer installed on the tank. Troublesome low-frequency vibrations can emanate from the sloshing of liquid contents being mixed. Remotely generated vibrations can be transmitted to the tank through piping and plumbing. Remote sources include pumps, motors, drive shafts, and passing vehicles.

Once vibration enters the scale system via the load cells, it becomes electronic noise. Instead of being strong and steady, the signal from the load cells oscillates rapidly at varying frequencies. Some vibrations may cancel each other out. Others may combine to produce even greater distortions. The signal, at best, is only 1-45 microvolts, therefore it is quite sensitive to noise. Any noise during a weighment could produce erroneous results.

There are four strategies for minimizing the effects of vibration:

1. Design out the vibration. Combine materials before they enter the tank scale. Or add interior baffles to disrupt the steady sloshing caused by a mixer.

2. If possible, take weighments when vibration is minimal, i.e., with agitators, mixers, and pumps off.

3. Electronically filter out the noise caused by vibrations. (see Indicator Selection, page 47).

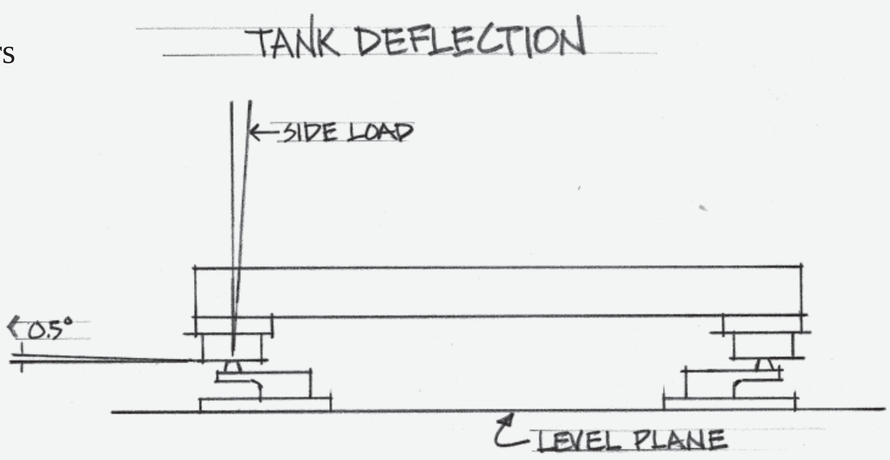
4. Isolate the tank from its surroundings.

Smart designers will opt for all four strategies when they can. They know from experience that vibration is difficult to predict and its sources elusive. You don't really know how much noise will be introduced into the signals from the load cells until the scale is calibrated and verified. This is also a good time to suggest barriers around the tank if there is much adjacent vehicle traffic.

❑ STRUCTURAL INTEGRITY AND DEFLECTION OF THE TANK

Just as a tank's supporting structure can deflect under load, so too can the tank itself, especially if the tank has a large diameter or if the legs are relatively long and tend to splay out. The design of sliding-suspension weigh modules will compensate for minor tank deflection just as they compensate for thermal movement, but serious tank deflection (more than 0.5° from level) will introduce non-linear errors and imprecise weighments.

It's the design engineer's job to make sure that tank deflection is within specification. This may require that the legs be braced and tied together.



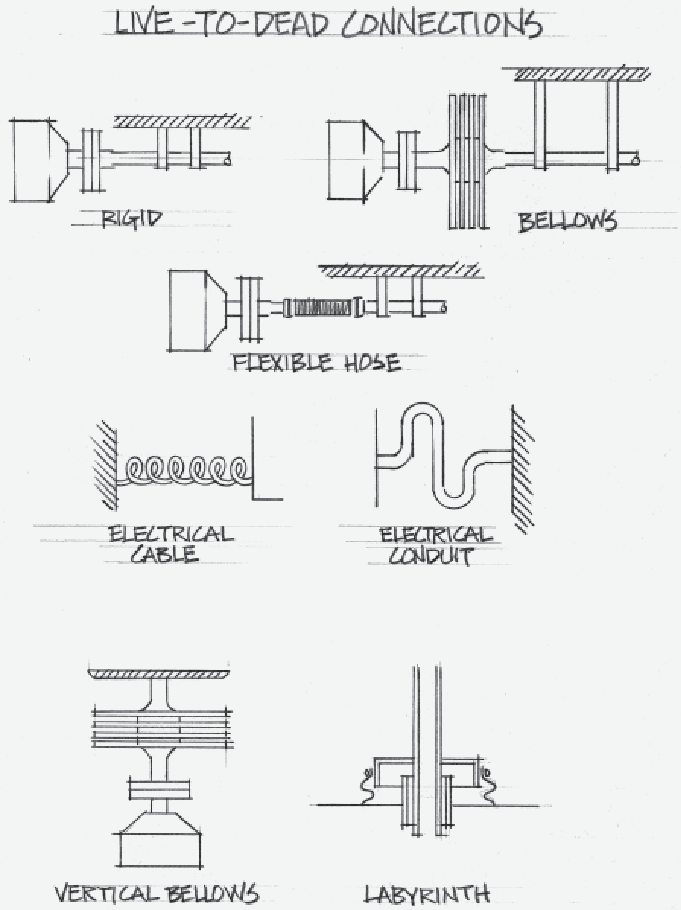
❑ LIVE-TO-DEAD CONNECTIONS

What you want to weigh is the live load. This will include the tank, its contents, and other components that are part of the tank, e.g., mixers, vibrators, heating and cooling elements, and insulation.

The dead load is composed of those things that are attached to the tank, but which can exert varying and unpredictable forces. Dead loads, which you don't want to weigh, usually take the form of piping into and out of the tank, along with associated valves and pumps, and may also include electrical cabling, plumbing, and hydraulic lines.

Pipes may be full or empty, depending on what's happening at the moment. They may also be subject to residue build-up. Ambient and process temperature variations affect dead loads, alternately pushing and pulling on the connections to the tank. Pipes also move when pump pressure is applied, and they vibrate, sometimes to the point of jumping, when material moves through them.

Dead loads should be supported independently of the tank structure. Horizontal pipes are much easier to support than vertical pipes.



All piping connections should be made with flexible hosing or bellows expansion joints. They absorb differential movement and help isolate the tank from extraneous vibration. Make sure all piping is precisely aligned. Flexible joints are not intended to correct misalignments. Flange bolts should serve only to make joints leak-proof.

Electrical cabling should be independently supported and looped as it enters the tank structure.

Whenever possible, live-to-dead connections should be made near the fixed-pin weigh module in a sliding-suspension system. This will minimize the interaction between the expansion and contraction of the tank and the movement of piping.

Ladders, stairways, and walkways should be independent of the tank and its supporting structure.

❑ SHOCK LOADS

Shock occurs when a load is dropped on a scale. Expect shock loads when adding dry materials to a tank scale. Higher drops, larger particle sizes, and bigger volumes combine to increase the shock load. You can also get shock loads when adding liquids if the drop is high and the infeed pipe is large.

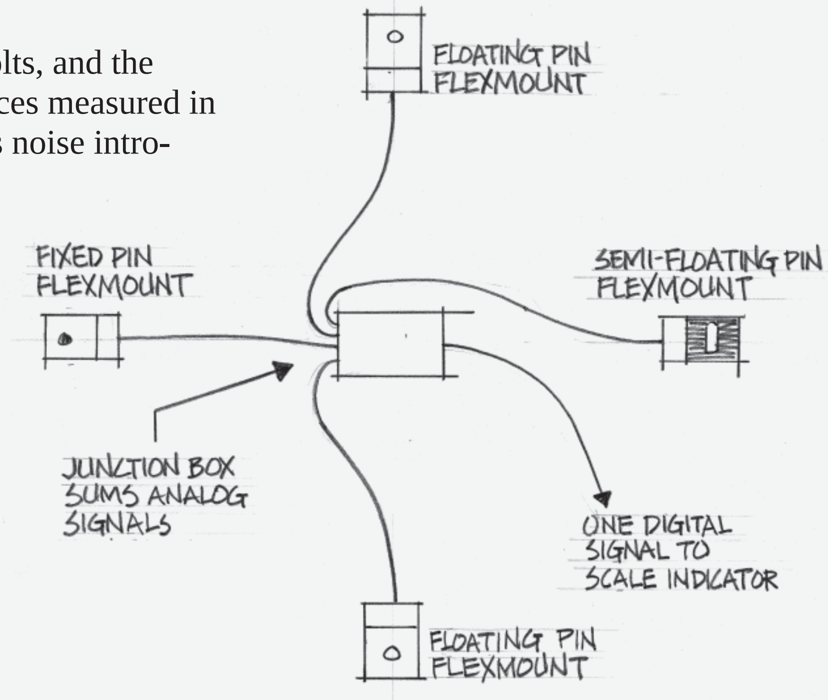
Interior baffles and deflection cones reduce shock loading and also serve to distribute dry ingredients evenly within the tank.

The potential for shock loading has to be included in the specifications for the load cell and weigh module. Mettler Toledo load cells and weigh modules are built to safely take a shock load of 150% of the maximum rated capacity.

❑ ELECTRICAL CABLING

Cabling is nothing more than the wiring from the load cells to junction boxes and on to the scale weight indicator or signal processor. This is no problem for an experienced contractor who knows what he is doing and starts with the right materials. He’s the one you want to hire.

Cabling is sensitive for two reasons:



1. The signal is a weak 1-45 millivolts, and the scale electronics must read differences measured in millionths of a volt. Any extraneous noise introduced through the cabling could yield erroneous weighments. A common source of noise is radio frequency or electromagnetic radiation. RF or EM radiation can usually be traced to nearby motors (especially variable speed motors), power lines, power supplies, and even cellular phones. The scale cabling must be fully insulated and grounded. Use cables sheathed in woven metal, usually stainless steel, to block out unwanted radiation.

2. The cables are often on the ground and exposed to mechanical damage, sharp tugs, water and water vapor, and chemicals. Conductors need to be fully insulated and protected. The same stainless steel sheathing that blocks out RFI and EMI will afford some protection, but conduit (containing only the scale cabling) may be needed to protect the cabling from feet, dropped tools, and forklifts. Waterproof, screw-in connectors should be used. If a lot of debris is expected, rubber boots should cover the connectors to keep them clean. Rubber boots do not adequately protect from water or water vapor. Junction boxes should be waterproof, corrosion resistant NEMA 4X/IP65, and attached to the supporting foundation or structure.

As long as we’re talking about electrical sensitivity, it’s appropriate to add a note of caution about stray electrical currents. Weak currents can affect signals during weighments. Strong currents can burn out circuits. The tank and its electronics should be correctly grounded with no inadvertent ground loops. Care should be taken during construction and later if the tank is modified to prevent damage from arc welding.

❑ PRESSURE IMBALANCE

Pressure imbalances occur when unvented tanks are loaded or unloaded. Adding a thousand cubic feet of liquid from a pressurized pipeline means that a thousand cubic feet of air must be vented. If it's not, the weight of that air is registered on the tank scale. The opposite happens when an unvented tank is emptied and a partial vacuum is created.

The obvious cure is one or more vents. This will eliminate or minimize pressure imbalances, allowing accurate weighments to be made as soon as the tank is filled or emptied. Vents should be vertical and provided with clean-out doors and fume stops or dust collectors.

❑ ENVIRONMENTAL CONSIDERATIONS

The weigh modules on outside tanks need to be kept clear. Accumulations of snow should be cleared away, hence appropriate access needs to be part of the design. Support pads for the weigh modules should be designed to drain properly. You don't want water from melting snow to freeze around or in the weigh modules. And you don't want storm water draining over them and depositing debris that can interfere with their movement.

Any exterior tank should be designed to shed water and snow. That means no flat tops.

A well-designed load cell will automatically compensate for changes in the ambient temperature through its internal electronics. Differential warming, however, will produce a wavering reading until the entire load cell is at the same temperature. Differential warming may be caused by radiant energy from any nearby source, e.g., a heated tank.

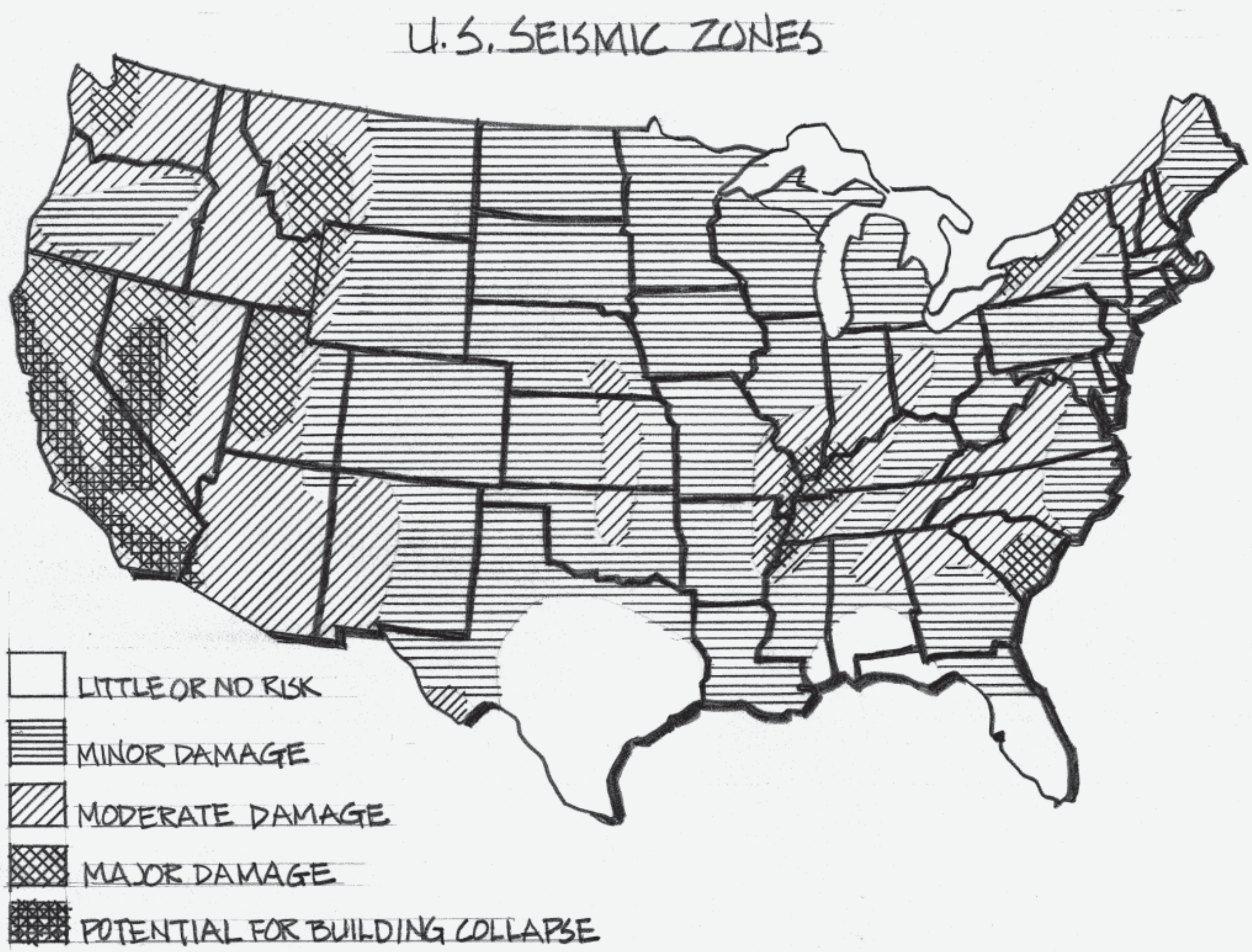
The areas around the weigh modules for both exterior and interior tanks should be swept or hosed out regularly, another reason for clear access. Once the tank is yours, make sure everybody knows that the area under it and around the weigh modules is no place to store tools, supplies, or trash.

Most weigh modules, tension or compression, are corrosion resistant under normal circumstances. If the atmosphere around the tank will be exceptionally corrosive, talk to your weigh module supplier about extra measures such as special coatings and shielding. Positive air movement in the area may help, too.

❑ SEISMIC ACTIVITY

Your tank scale has to resist earthquakes that might reasonably be expected in your area. Check with your local and state code authorities for design specifications. The specifications may vary according to what's in the tank (corrosives, flammables, etc.) and according to where it's located (roof top, free-standing in a diked tank farm, etc.).

Earthquakes generate two kinds of movement, side-to-side and up-and-down. Both can oscillate for several seconds. Because both movements can occur at the same time, some of the resulting forces will cancel each other while other forces will be magnified.



The side-to-side movement yields an initial shear force, most often followed by a swaying motion. The shear force tends to shear the tank from the foundation at the weigh module. The swaying motion is a tipping force that moves first in one direction and then reverses itself, repeating the cycle for as long as the quake lasts. Some of the weigh modules are thus subject to massive downward forces while the others are subject to massive uplift forces. The forces are then reversed as the tank sways back in the opposite direction.

The up-and-down force subjects all the weigh modules to a massive downward force as the ground moves up. Then, as the ground moves down, all the weigh modules are subject to massive uplift forces.

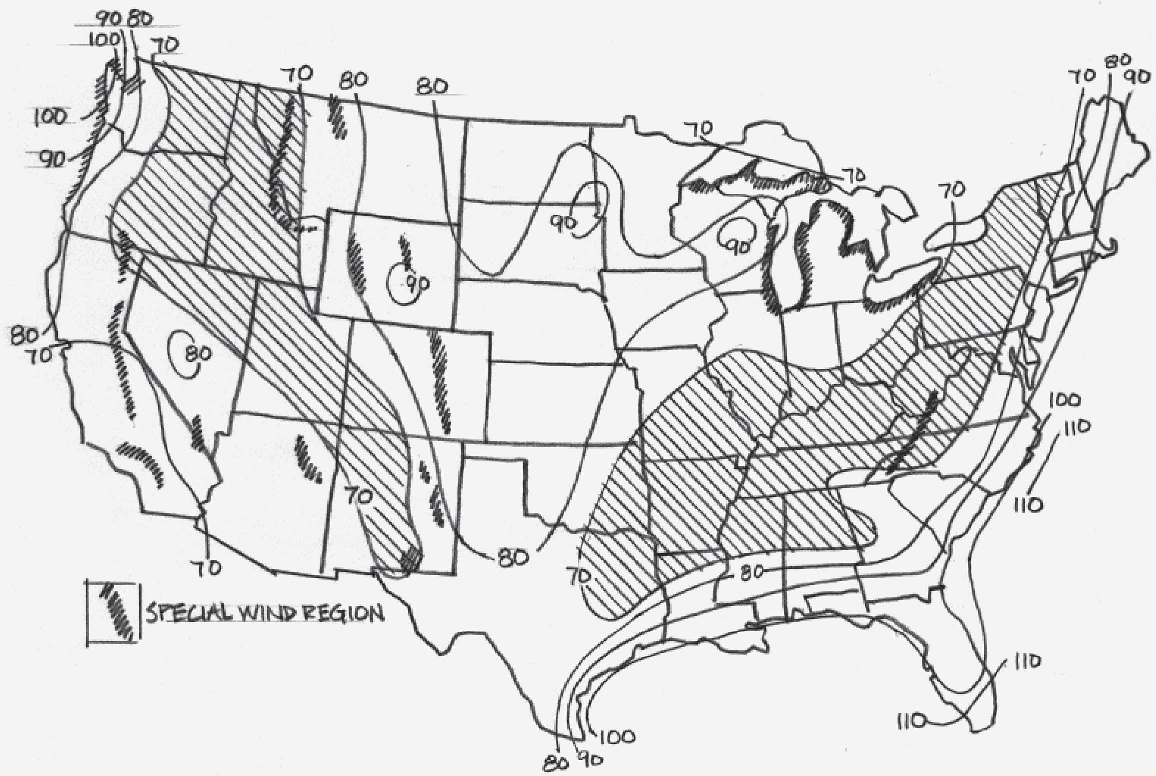
Typically, seismic requirements are met by comparing the calculated reaction forces to the weigh module maximum allowable load ratings for shear and uplift. If safe load ratings are exceeded, the capacity of the weigh module may have to be increased.

As an alternative or supplement to increasing the capacity of the load cells and weigh modules, mechanical restraints may be in order. If used, external mechanical restraints must not affect scale operation.

Consult a structural or civil professional engineer (P.E.) to ensure that reaction forces are properly calculated.

❑ WIND LOADING

Wind loading on outdoor tanks can be severe. The taller the tank, the higher it sits off the ground, the more closely spaced the legs—the greater the wind load reaction forces. Uplift is usually the more serious problem for empty tanks. For full tanks, downward pressure will be the more worrisome.



MINIMUM WIND SPEEDS
(mph)

Wind load calculations need to be run for full and empty tanks using an acceptable figure for maximum wind speed. Check local codes for guidelines.

Wind load calculations are tedious and, for the inexperienced, difficult. Consult a structural or civil professional engineer (P.E.) to ensure that reaction forces are properly calculated.

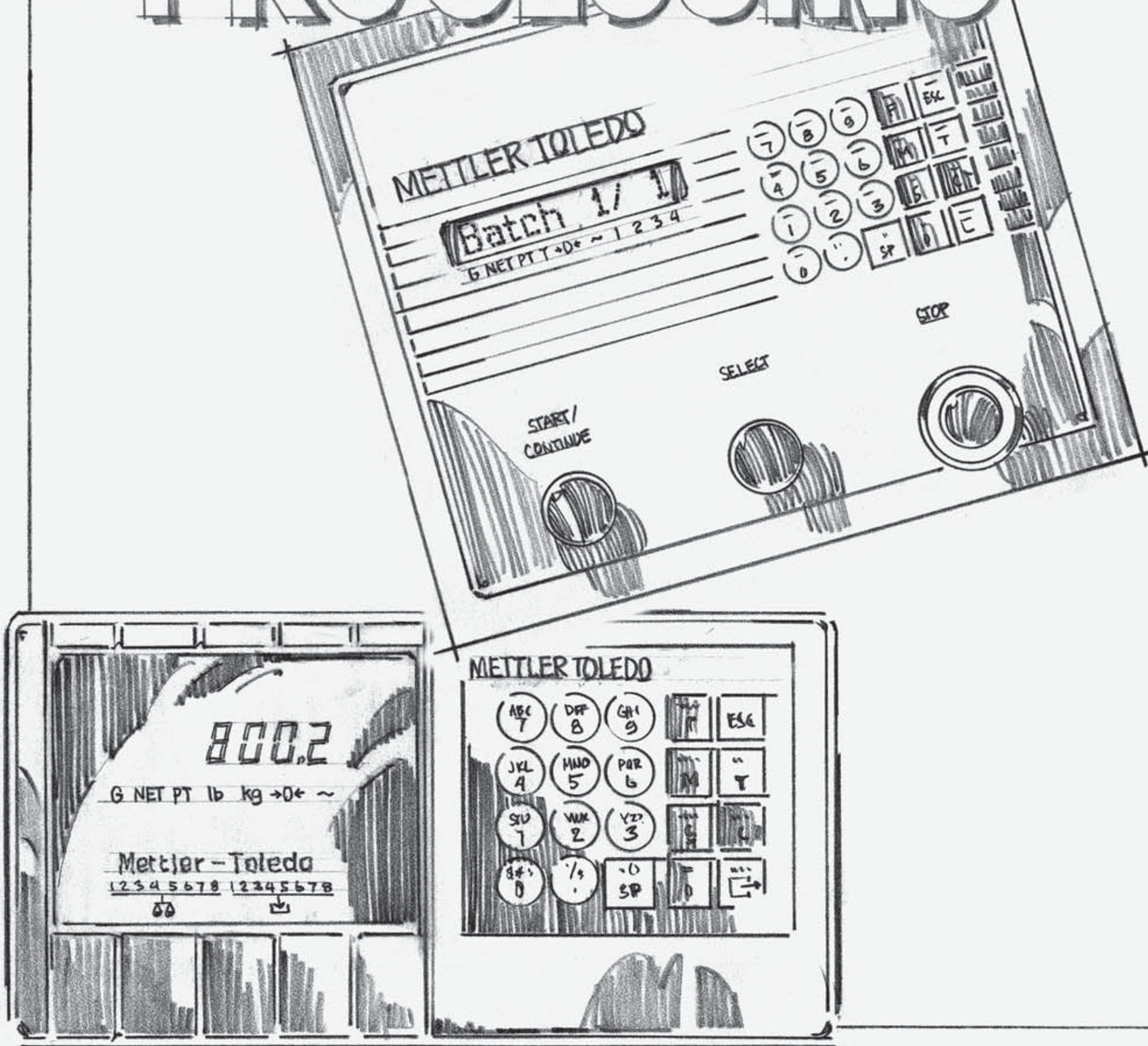
❑ MECHANICAL RESTRAINTS

Stay rods are alternatives to increasing the capacity of the weigh modules in cases where seismic or wind load forces exceed the safe load rating. Stay rods should be part of the tank's supporting structure and not, for example, attached to the building structure. This will minimize differential movement so that, under normal operation, the stay rods will not interfere with the tank due to movement caused by thermal expansion and contraction, shock loads, filling, or emptying.

For hoppers suspended from tension load cells, stay rods (or safety rods) are a necessity. Check rods or bumpers may be needed to control swaying.

Check rods or bumpers may also be needed on some tanks employing compression load cells. The torque generated by a mixer, for example, may impart a twisting motion to the tank that needs to be controlled. Or shock loads caused by incoming product hitting the side of the tank may cause the tank to tip.

the INDICATOR and SIGNAL PROCESSING



Every scale needs an indicator, a device to convert the analog signal into an intelligible weighment and display the results. The display will probably be digital with light-emitting diodes showing pounds or kilograms.

The simplest configuration would be nothing more than a box with an LED display mounted on a wall, control panel, or column. The weight would probably show continuously. The indicator might also feed information to a host computer via an RS232 connection when polled. Or it could be tied into some sort of safety lock-out, e.g., the evacuation pump won't turn on unless the tank contains a minimum quantity of material.

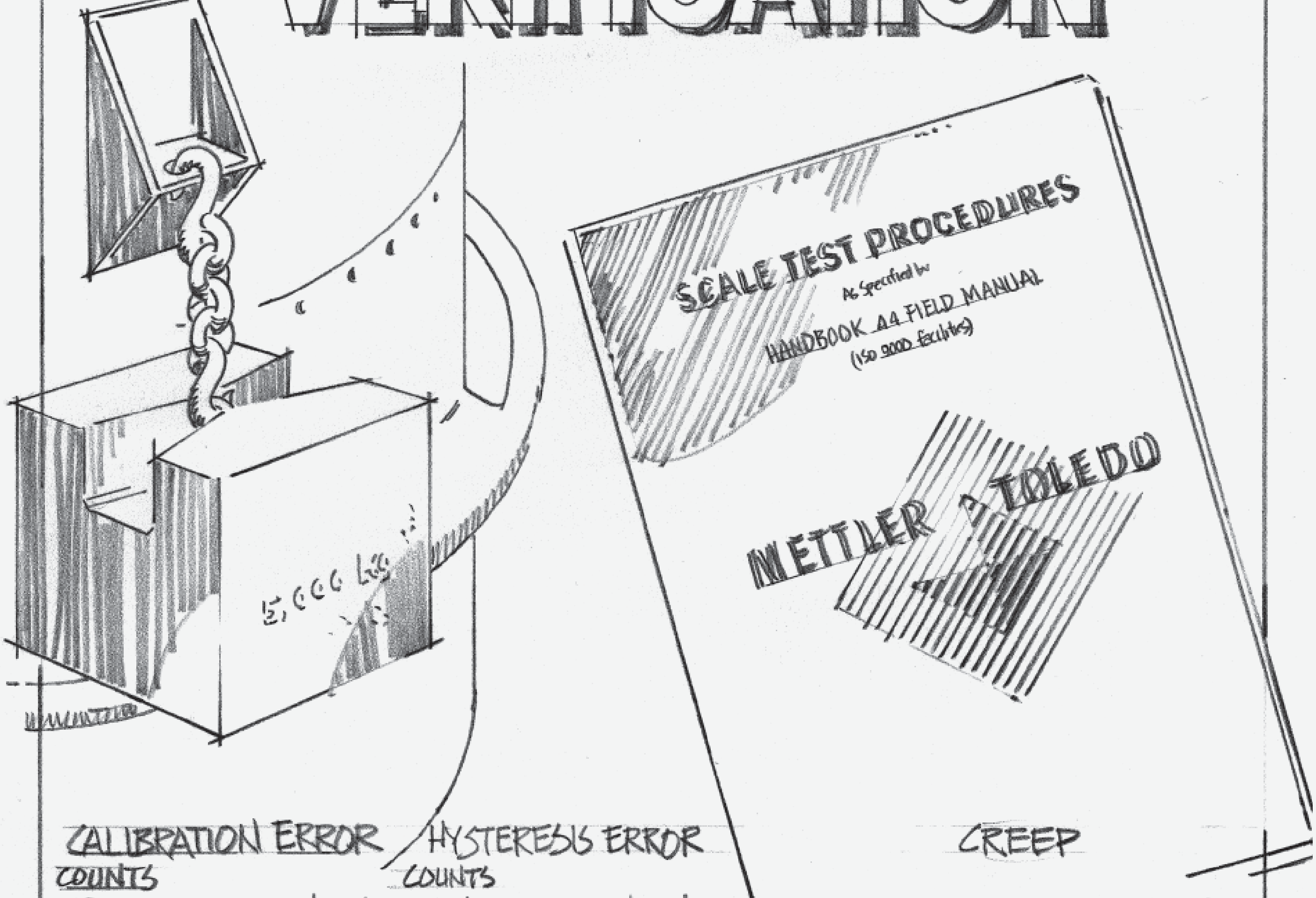
Your tank scale may need more advanced signal processing. Some loads, for example, never stabilize. They're always in motion, so the indicator always shows a shifting weighment. For these instances, called dynamic weighing, an indicator that computes and displays an average weighment is needed. Other tanks are used with mixers or agitators that affect the signal from the load cells. In these circumstances, an indicator that uses a frequency filter to eliminate extraneous noise patterns may be best because it is substantially faster than averaging. The capabilities of indicators to filter out noise vary from manufacturer to manufacturer. Some need to be tuned during installation to the specific noise on that tank, then hard-wired. Others need to be manually tuned by the operator at frequent intervals. Still others are automatic and tune themselves continuously to eliminate recurrent noise patterns.

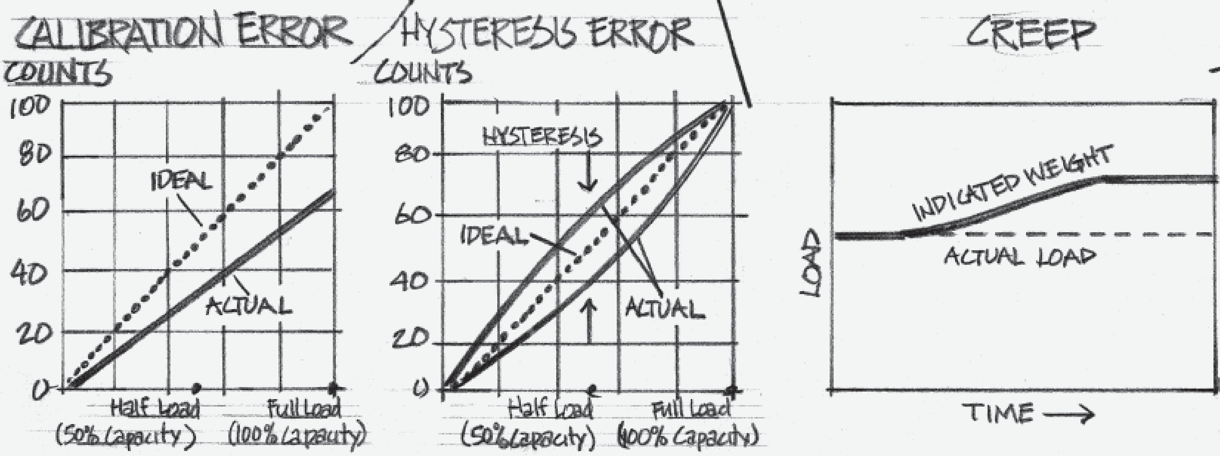
Simple tank scales report only a current weight. A more demanding situation occurs when the tank scale becomes part of a batching operation, i.e., measuring quantities of various ingredients added to the tank or reactor vessel.

During batching, the tank scale is used to control upstream (the addition of the ingredients) and downstream (evacuation pumps) processes. A good batching controller must be easily programmable—in case the recipe changes—by the operator or by downloading from a host computer. It should also communicate directly with PLCs, the devices which actually control pumps and augers and mixers. And it must yield accurate results, not just accurate weighments. A good batching controller will anticipate the lag time of the pumps or augers that add ingredients, and it should automatically adjust to changes in that lag time due to, for example, material build-up in the in-feed piping.

A top of the line controller should also communicate with a host computer, supplying data for real-time control or to a record log.

CALIBRATION and VERIFICATION

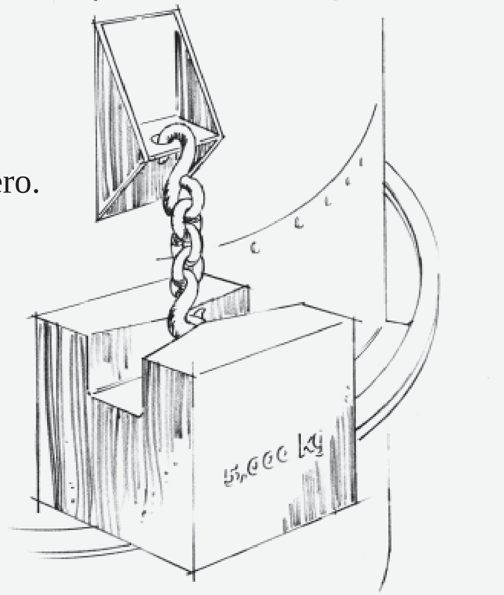




With your tank scale built and ready to put into service, the only task that remains is calibration and verification. Calibration is simply instructing the system when to indicate zero (really the tare, i.e., the weight of the empty tank) and when to indicate the maximum weight, i.e., when the tank is full. Verification documents the actual performance of the scale from zero to maximum and from maximum to zero.

There are four ways to calibrate and verify:

HANGING TEST WEIGHTS

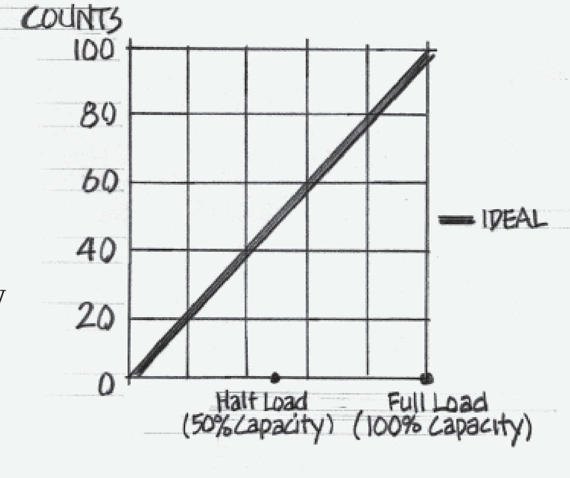


Hanging test weights will also require a hoist or forklift to place the weights.

1. Test Weights. The most accurate and reliable way is to hang test weights from the tank. Readings are taken as weights are added and removed, yielding a graph of the scale's performance from zero to maximum and back to zero. This method is used where accuracy is paramount, and in smaller tanks that will hold something less than 10,000 kg or so.

2. Test Weights and Substitution. For larger installations where it would be physically impossible to hang test weights equivalent to the maximum capacity of the tank, a substitution method is employed. For example, 1500 kg of test weights might be hung, then removed. Sufficient water would then be added to the tank to equal the indicator reading obtained with the test weights, then the same test weights are re-hung for a second reading. Water is substituted for the test weights until the capacity of the tank is reached. If carefully performed, the method works quite well and yields a reliable performance graph.

PERFECT PERFORMANCE

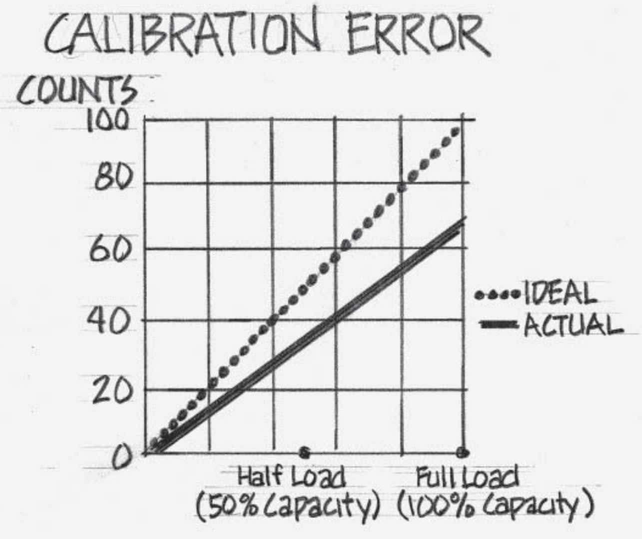


3. Material Transfer. In this method, a material, usually water, is weighed on an existing scale and transferred to the tank scale being calibrated. It can be done in a single transfer or in stages until the maximum capacity of the tank is reached. This method tends to yield only a rough indication of scale performance. It depends on the accuracy of the existing scale and the integrity of the transfer process. Even under the best of circumstances, you won't know if allowable errors are cumulative or compensating.

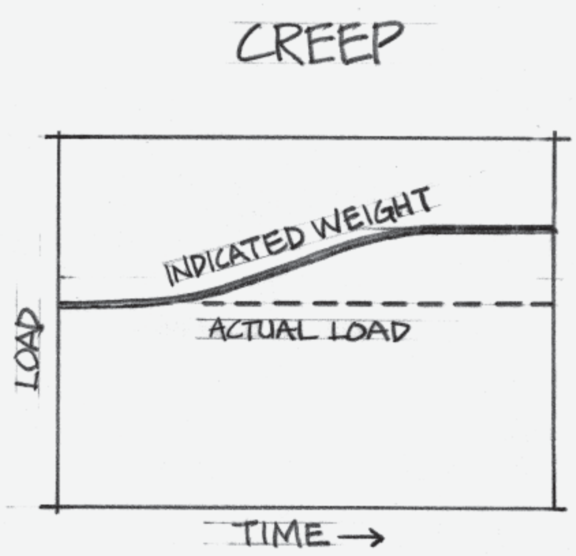
4. Electronic calibration. The cables from the load cells are replaced by leads from a load cell simulator which sends out a signal equal to what the load cells should produce. With the simulator adjusted to zero output, the indicator is set at zero. The simulator is then adjusted to full output, a signal equal to that which all the load cells should produce at their rated capacity. The indicator is adjusted to show the total capacity of all load cells in the system. Electronic calibration is appealing because of its speed and simplicity. The drawback to electronic calibration is that it only calibrates the electronics. It does not verify the performance of the scale itself, assuming instead that the tank and all its mechanical connections work perfectly.

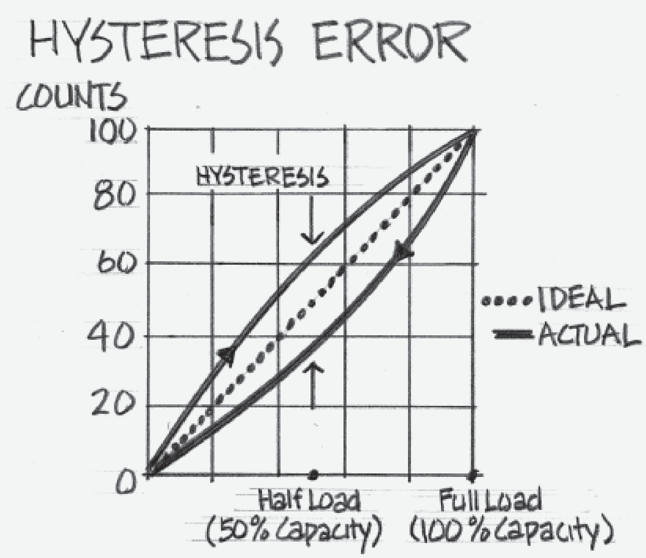
You should also know about creep and hysteresis. Creep is the tendency of a load cell to continue to deflect under a constant load. Thus a weighment of a full tank immediately after filling will be lower than a weighment taken several hours later. Hysteresis is the tendency of a scale to read a little low or high as it is being loaded and emptied. The verification process will document the creep and hysteresis characteristics of your tank scale. Both should be within specification.

You have to decide the best method of calibration and verification for your scale. Your scale supplier can advise you. If you know at the design stage what you'll need, calibration—and recalibrations—will take a minimum of time and effort.



If your tank scale is going to be used to determine price (legal-for-trade), you'll have to abide by the requirements of your state and local regulatory agencies. They may even want to witness the calibration and verification. If your tank scale is part of an ISO process, use a calibration and verification process that uses test weights traceable to a legal standard such as NIST or OIML. If it's a batching operation intended to produce a predictable amount of product, then accuracy is the goal. If it's a reactor vessel where the proportions of ingredients are key, repeatability may be all you need. If it's a storage tank, and you want to know if it's empty or full, then only the roughest approximations will be needed.



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❑ SCHEDULED MAINTENANCE

While you will be responsible for keeping your scale clean and free of any accumulation of debris, your scale supplier will probably offer you a maintenance program. We recommend you give it strong consideration because it's the best way to keep your scale performing in conformance with your specifications.

All scales should be inspected periodically by experienced technicians for signs of trouble. Ask about the qualifications of the technicians who will be working on your scale.

When your scale is being inspected, tested, adjusted, calibrated, verified, or otherwise serviced, it's probably going to be down and unavailable for use. That will cost you money. Obtain and compare realistic estimates from prospective scale suppliers for service costs and time. How often should scales be inspected, and how long does it take? How much time does a test require? How often should testing take place? How difficult is calibration and verification?

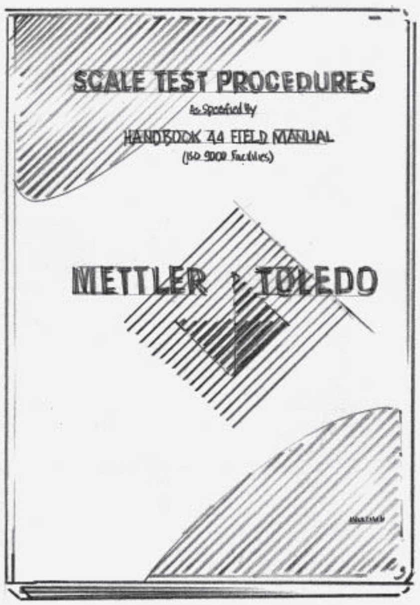
❑ EMERGENCY SERVICE

More questions you should ask of your potential scale supplier:

- What kind of parts inventory does he carry?
- What's the drive time from his location to your scale?
- What sequence of tests does the technician perform when he's faced with a scale that isn't operating properly?
- How long do they take?
- How long does it take to switch out a load cell on a weigh module?
- Is service available 24 hours a day?
- How fast can the manufacturer get parts to the local service organization?
- What equipment does the local service organization have, e.g., jacks, test weights, heavy duty trucks, and booms?

❑ ISO SUPPORT

If your tank scale will be part of a process registered to ISO 9000 standards, it must be supported by a thorough program of maintenance and testing. Your scale supplier should be able to recommend an appropriate program, the purpose of which is to prove that the scale always performs within specification. His recommendation should also include the appropriate documentation for testing and calibration.



Mettler Toledo has a booklet on ISO test procedures.

You can run the program yourself, but it will probably be cheaper and easier to contract it out. Test weights, for example, have to be traceable back to standards maintained by the federal government, e.g., the NIST. A qualified service contractor has those weights and can spread the cost of their periodic verification among many scale owners. He will also have the required formal training programs in place for his technicians, acceptable standards and procedures, and the necessary forms.

❑ A FINAL WORD

Well, that’s it. We hope we’ve been able to inject some common sense into a process that can be complicated and daunting. And we hope our unique perspective on the scale business has proven more helpful than intrusive.

However helpful we may have been, it’s unlikely that we’ve covered every subject of concern to the depth you may have wished. So, if you want more help, contact your local authorized Mettler Toledo representative.

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