Weigh Module Systems Handbook

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METTLER TOLEDO

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A15598500A	12/99	Added Information about 0958 Flexmount HD and VLM2 Value Line weigh modules.

INTRODUCTION

Information regarding METTLER TOLEDO Technical Training may be obtained by writing, calling, or faxing:

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⚠ WARNING

This publication is provided solely as a guide for individuals who have received technical training and are familiar with the technical manuals of the METTLER TOLEDO products.

This guide is not meant to replace the technical manual for various products.

Please review the specific technical manuals for detailed instructions and safety precautions before operating or servicing the various METTLER TOLEDO products.

PRECAUTIONS

READ this manual BEFORE operating or servicing this equipment.

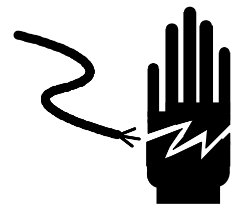
FOLLOW these instructions carefully.

SAVE this manual for future reference.

DO NOT allow untrained personnel to operate, clean, inspect, maintain, service, or tamper with this equipment.

ALWAYS DISCONNECT this equipment from the power source before cleaning or performing maintenance.

CALL METTLER TOLEDO for parts, information, and service.



⚠ WARNING

PERMIT ONLY QUALIFIED PERSONNEL TO SERVICE THIS EQUIPMENT. EXERCISE CARE WHEN MAKING CHECKS, TESTS, AND ADJUSTMENTS THAT MUST BE MADE WITH POWER ON. FAILING TO OBSERVE THESE PRECAUTIONS CAN RESULT IN BODILY HARM.

⚠ CAUTION

DO NOT PASS WELDING CURRENT THROUGH THE LOAD CELLS! WHEN WELDING ON A SCALE, ALWAYS GROUND THE WELDING DEVICE AS CLOSE TO THE WORK AS POSSIBLE. NEVER WELD CLOSER THAN 4 FEET (1.2 METERS) TO ANY LOAD CELL WITHOUT REMOVING THE LOAD CELL.

⚠ WARNING

CENTERLIGN WEIGH MODULES DO NOT PROVIDE OVERTURN PROTECTION. IF ANY UPLIFT FORCES ARE GENERATED, UPLIFT/OVERTURN PROTECTION MUST BE ADDED SEPARATELY.

⚠ WARNING

STRUCTURES SUCH AS TANKS AND CONVEYORS MUST BE PROPERLY DESIGNED TO MAINTAIN THE RELATIONSHIP OF THE LOAD SUPPORT POINTS THROUGH THE ENTIRE WEIGHING RANGE.

⚠ WARNING

BE SURE TO BLOCK THE SCALE WHEN IT IS IN THE RAISED POSITION. OBSERVE ALL APPROPRIATE SAFETY PROCEDURES WHEN INSTALLING AND SERVICING THE WEIGH MODULES.

⚠ WARNING

USE SAFETY CHAINS OR RODS TO PREVENT TANK FROM FALLING IN CASE OF COMPONENT FAILURE.

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1 Introduction

This handbook is intended as a guide to selecting and applying METTLER TOLEDO weigh modules for process weighing applications. It provides the scientific data and accepted guidelines needed to help you design an accurate, reliable weighing system.

A weigh module is a weighing device that consists of a load cell and the mounting hardware needed to attach the load cell to a tank, hopper, or other vessel. Typically, three or four weigh modules are attached to a tank so that they support the full weight of the tank. This effectively converts the tank into a scale. A weigh module system must be able to (1) provide accurate weight data and (2) support the tank safely.

There are two basic types of weigh modules: compression and tension.

Compression Weigh Modules

Compression weigh modules fit most weighing applications. These modules can be attached directly to the floor, piers, or structural beams. The tank or other structure is mounted on top of the weigh modules.

A typical compression weigh module is shown in Figure 1-1. It consists of a load cell, a top plate (which receives the load), a load pin (which transfers the load from the top plate to the load cell), and a base plate (which is bolted to the floor or other support surface). A hold-down bolt is used to prevent the vessel from tipping.

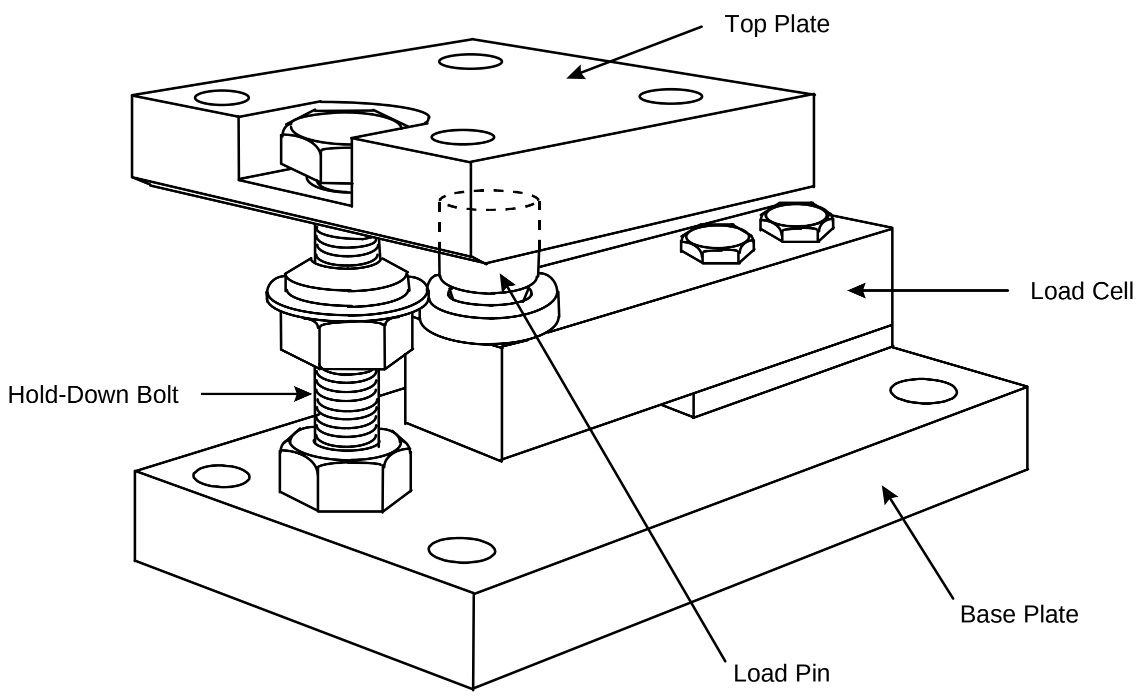


Figure 1-1: Compression Weigh Module

Tension Weigh Modules

Tension weigh modules are used for tanks or hoppers that must be suspended from a building's superstructure or upper floor.

A typical tension weigh module is shown in Figure 1-2. It uses an S-shaped load cell that is threaded on both ends. Each threaded end of the load cell accepts a spherical rod-end bearing and clevis arrangement that connects to existing threaded vessel support rods.

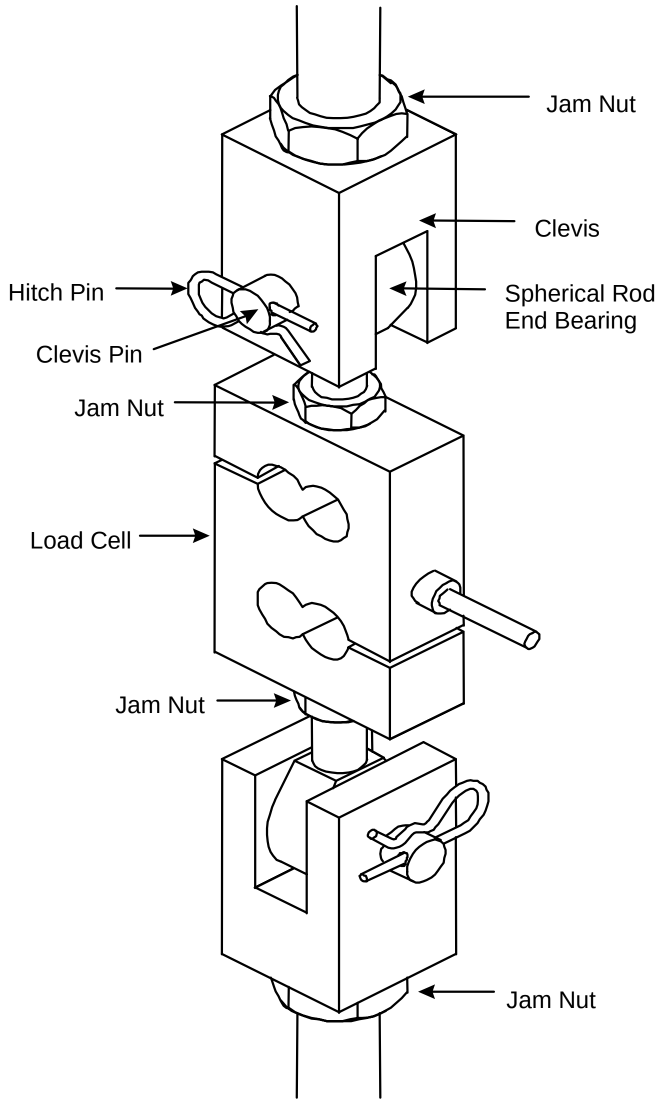


Figure 1-2: Tension Weigh Module

2 Weigh Module Applications

Weigh modules can be used to convert nearly any structure into a scale. They can be part of a structure's original design or can be added to an existing structure. This chapter describes the most common weigh module applications.

Tanks, Hoppers, and Vessels

Tanks, hoppers, and vessels are used for material handling in many industries. By attaching a system of weigh modules to one of these containers, you can weigh the contents accurately and reliably. This handbook uses "tank" as a generic term to refer to any tank, hopper, or vessel supported by weigh modules. But each is a specific type of container used for the purposes described below:

Tanks: A tank is a closed container used to store liquids or solids. Tanks range in size from small residential tanks for propane or heating fuel to large industrial tanks that can hold thousands of pounds of material. Figure 2-1 shows a tank supported by compression weigh modules.

Hoppers: A hopper is a container that is open at the top. It is generally used to dispense materials or collect ingredients for later processing. Hoppers tend to be smaller than tanks and are often suspended from a superstructure. Figure 2-2 shows a hopper supported by tension weigh modules.

Vessels: A vessel is an elaborate tank with equipment to allow heating, cooling, mixing, or other processes. Many vessels house chemical reactions and therefore must be capable of accepting precisely measured materials.

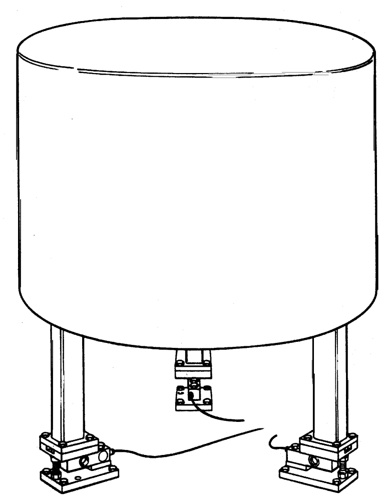


Figure 2-1: Tank Supported by Compression Weigh Modules

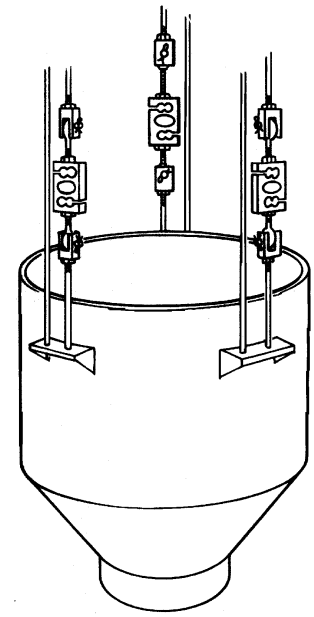


Figure 2-2: Hopper Supported by Tension Weigh Modules

Conveyors

To weigh objects that are transported on a conveyor system, mount a section of the conveyor on weigh modules (see Figure 2-3). Because the objects being weighed on a conveyor are usually in motion, these applications require a weigh module capable of withstanding high horizontal shear loads while still delivering repeatable weighments. METTLER TOLEDO's Centerlign™ weigh modules allow the conveyor's weighing section to move back and forth when exposed to horizontal shear loads. But the load cell's self-righting suspension system always returns the conveyor to its "home" position to ensure repeatable weighing.

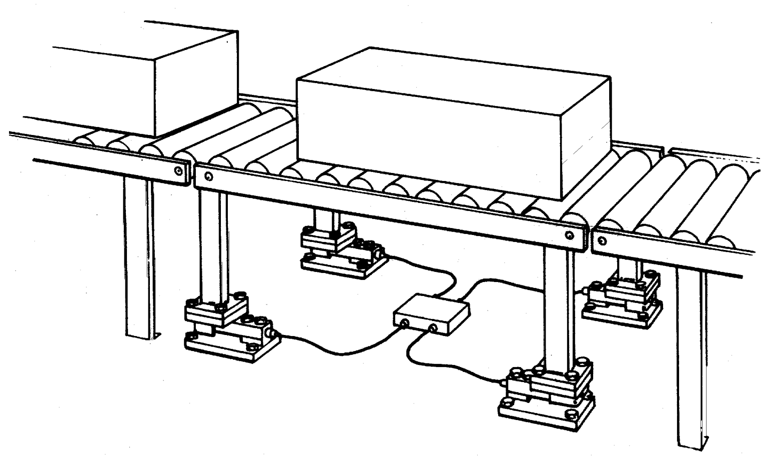


Figure 2-3: Conveyor Supported by Weigh Modules

Mechanical Scale Conversions

There are two ways to convert older mechanical lever scales (see Figure 2-4) for electronic weighing. The first method is a lever conversion. It involves adding an S-Cell tension weigh module, while retaining the levers and weighing platform from the existing mechanical scale. The second method is a lever replacement. It involves removing the levers and adding compression weigh modules beneath the existing weighing platform.

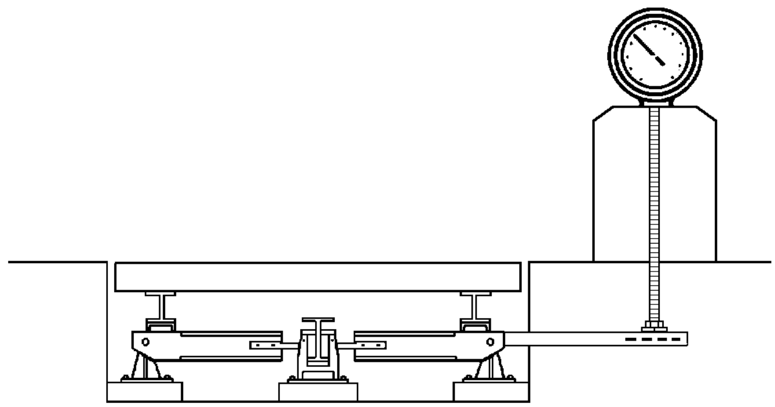


Figure 2-4: Mechanical Scale

Lever Conversion

A lever conversion retains the mechanical scale's dial head, so that the scale can be used for electronic or mechanical weighing. An S-Cell tension weigh module is inserted into the existing steelyard rod located in the column of the dial head. The dial head is locked out to allow the S-Cell to sense the tension load applied by the transverse lever that extends from the scale pit. In case of a power or load cell failure, the dial head can be unlocked for fully mechanical operation. Figure 2-5 shows a lever conversion.

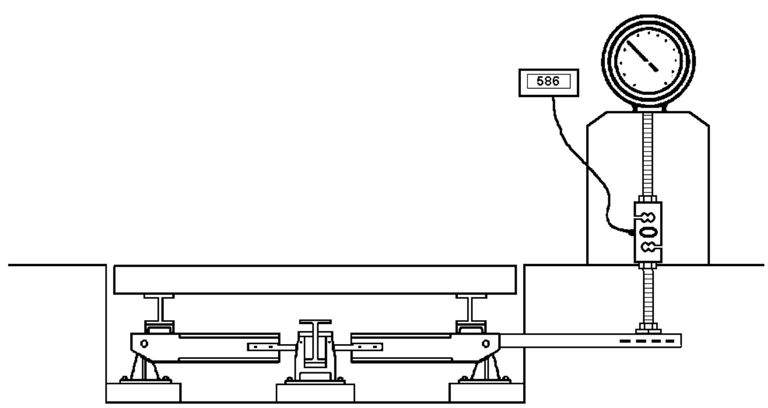


Figure 2-5: Electro-Mechanical Scale

How to determine the load cell size needed for a conversion:

- Determine the *initial pull* force at the end of the transverse lever.
- Determine the weight of the existing weighbridge platform (*deadweight*).
- Determine the *capacity* of the existing scale.
- Determine the *multiple* of the lever system.

Insert the variables listed above into the following formula:

$$\text{Load Cell Size} = \text{Initial Pull} + \frac{\text{Deadweight of Platform}}{\text{Multiple}} + \frac{\text{Capacity}}{\text{Multiple}}$$

Lever Replacement

A lever replacement eliminates the mechanical scale's levers and dial head. The existing weigh platform can be modified to accept compression weigh modules. This conversion results in a fully electronic scale (see Figure 2-6).

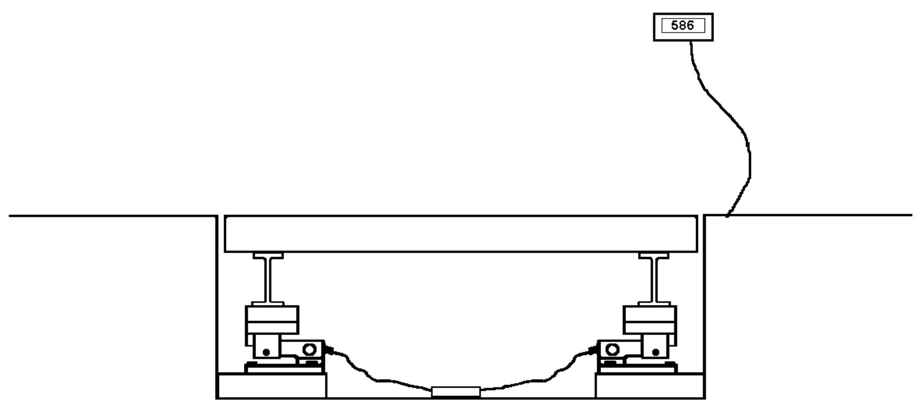


Figure 2-6: Fully Electronic Scale

3 General Considerations

Compression versus Tension Load Cells

There are two basic types of load cells for use in weigh modules:

Compression load cells are designed so that a tank or other structure can be mounted on top of the weigh module. The weight being measured compresses the load cell.

Tension load cells are designed so that a tank or other structure can hang from the weigh module. The weight being measured stretches the load cell, creating tension.

Whether you use compression or tension weigh modules often depends on the specific application. Table 3-1 provides an overview of how general design factors affect the choice of weigh modules.

Design Factor	Compression Load Cells	Tension Load Cells
Floor Space	Requires enough floor space to accommodate tank size. Might require buffer space around tank.	Requires no floor space and can be suspended to allow movement beneath tank.
Structural Restrictions	Weak floors might require additional construction or a special installation to accommodate weight of filled tank.	Weak overhead supports/ceilings might require additional construction or special installation to accommodate weight of filled tank.
Weight Limit	Generally unlimited. To ensure accurate load distribution, there should not be more than eight vessel supports.	Structural considerations might limit suspension system capacity. With adequate support, suspension systems can safely support as much as 40,000 lb.
Load Cell Alignment	Designs may vary and must consider floor deflection, available support beams, and tank size, shape, and condition.	Cell alignment will not vary significantly because tension rods and other support equipment tend to accommodate most deflections.

Table 3-1: Comparison of Compression and Tension Load Cells

Static versus Dynamic Loading

METTLER TOLEDO offers five types of compression systems: Flexmount®, Flexmount HD™, Centerlign™, Ultramount™, and Value Line weigh modules. Which type should be used for an application depends on how the load will be applied. Flexmount, Flexmount HD, and Value Line weigh modules are designed primarily for *static* loading applications, where minimal lateral forces are present (see Chapters 6, 7, and 10). Most tanks and hoppers are static loading applications. Centerlign weigh modules are designed for *dynamic* loading applications, where the weighbridge is subject to high horizontal shear forces (see Chapter 8). Dynamic loading applications include conveyors, pipe racks, mixers, and blenders. Ultramount weigh modules are designed for smaller capacities (up to 100 kg per support point). They can be supplied with a load pin for static loading applications or with a ball-and-cup assembly for dynamic loading applications (see Chapter 9).

METTLER TOLEDO also offers Tension weigh modules for applications that require a tank or other structure to be suspended. These weigh modules are designed for static loading applications, where there is no side loading (see Chapter 11).

How Many Load Cells?

For an existing installation, the number of weigh modules is determined by the number of existing supports. If a tank has four legs, you will need to use four weigh modules.

For a new installation, a three-point support system is inherently more stable and accurate than a four-point support system. If wind, fluid sloshing, or seismic loading is a factor, the tank might require four supports for additional protection against tipping.

Most tank scale applications use either three or four weigh modules. A METTLER TOLEDO indicator can sum as many as eight weigh modules, although the weight distribution and shift adjust would probably be less than ideal.

To calculate the required capacity for each weigh module, divide the gross capacity of the system by the number of supports. A safety factor should be applied to the gross capacity in case the weight is underestimated or distributed unevenly. The procedure for sizing weigh modules is explained in the chapters about the individual types of weigh modules (Chapters 6 to 11). Environmental factors such as wind loading can also affect the capacity of the weigh modules required for an application (see Chapter 4).

Field Calibration

Another consideration is how the weigh module system will be calibrated. If you are adding weigh modules to an existing tank, you might need to modify the tank so that you can hang certified test weights from it. At a minimum, the tank should be able to support test weights equal to 20% of the net product weight (programmed capacity). Several methods of field calibration are described in Chapter 12.

Weighing System Performance

Accuracy, resolution, and repeatability are basic concepts used to measure a weighing system's performance.

Accuracy is how close the reading on a scale's indicator is to the actual weight placed on the scale. A scale's accuracy is usually measured against a recognized standard, such as NIST Certified Test Weights.

Resolution is the smallest weight change that a digital scale can detect. Resolution is measured in increment size, which is determined by the capabilities of the load cells and digital indicator. A digital weight indicator may be able to display a very small increment size, such as 0.01 kg (resolution); however, that does not mean the system is accurate to 0.01 kg.

Repeatability is a scale's ability to display a consistent weight reading each time the same weight is placed on the scale. It is especially important for batching and filling applications, which require that the same amount of a material be used for each batch. Repeatability and accuracy go hand in hand. You can have a repeatable system that is not accurate, but you cannot have an accurate system unless it is repeatable.

The following factors can influence the accuracy and repeatability of a weighing system. They are discussed in detail later in this handbook.

- Environmental Factors: Wind, Seismic Forces, Temperature, Vibration
- Weigh Module System Support Structures
- Tank and Vessel Design
- Piping Design (Dead-to-Live Connections)
- Load Cell Quality
- Total Load Cell Capacity
- Calibration
- Operational / Process Factors

Determining System Accuracy and Repeatability

Experience has shown that a tank scale fully supported by weigh modules on a firm foundation can be accurate to within 0.1% of the applied load (the weight placed on the scale). When this type of scale is calibrated correctly, it will give an accurate reading of the weight placed on it. Ideally, the percentage of total weight capacity should equal the percentage of total counts (increments). This relationship is illustrated in Figure 3-1.

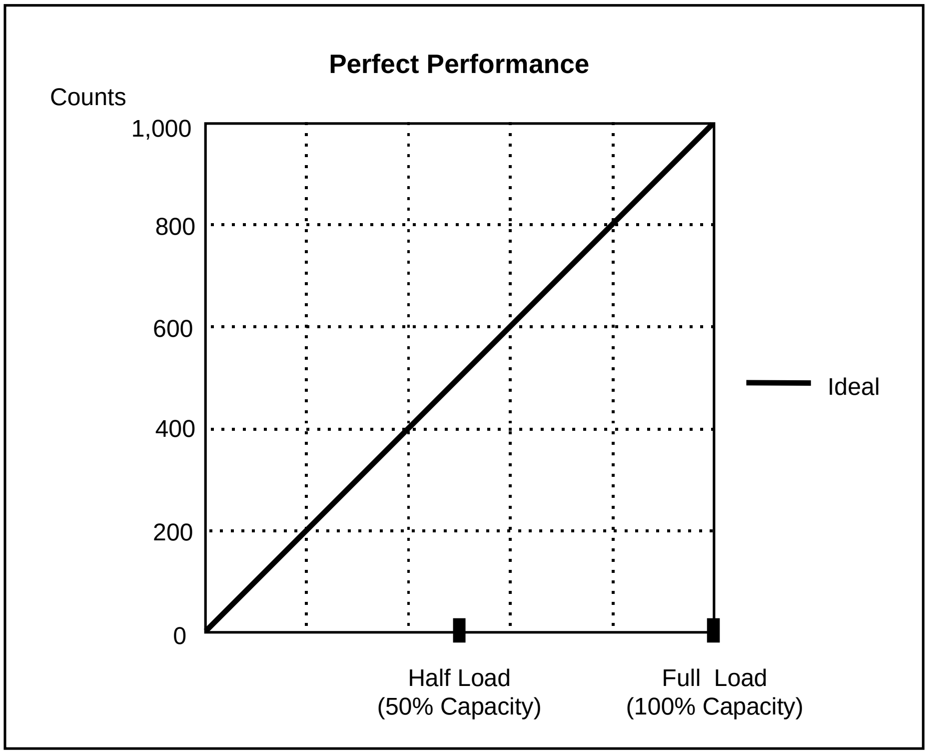


Figure 3-1: Ideal Weight Capacity vs. Counts

If a scale has 1,000 counts and a total capacity of 5,000 pounds, then each count should equal 5 pounds. When a 2,500 pound weight is placed on the scale, there should be 500 counts. With a 5,000 pound weight, there should be 1,000 counts. This relationship should not change regardless of whether weight is being added to or removed from the scale.

When a scale is not calibrated correctly, this ideal relationship does not hold true. There are four types of errors that cause inaccurate weighing:

- Calibration Errors
- Linearity Errors
- Hysteresis Errors
- Repeatability Errors

Calibration Errors

Some errors are caused because the weighing equipment is not calibrated correctly. When there is a calibration error (see Figure 3-2), the counts-to-load ratio is still a straight line, as it was in the ideal scale. But the line does not reach 100 percent of the counts at full load. The relationship between the weight and the counts is linear but not correct. This is usually caused by an error in the electrical calibration of the scale and can be corrected by recalibrating the scale.

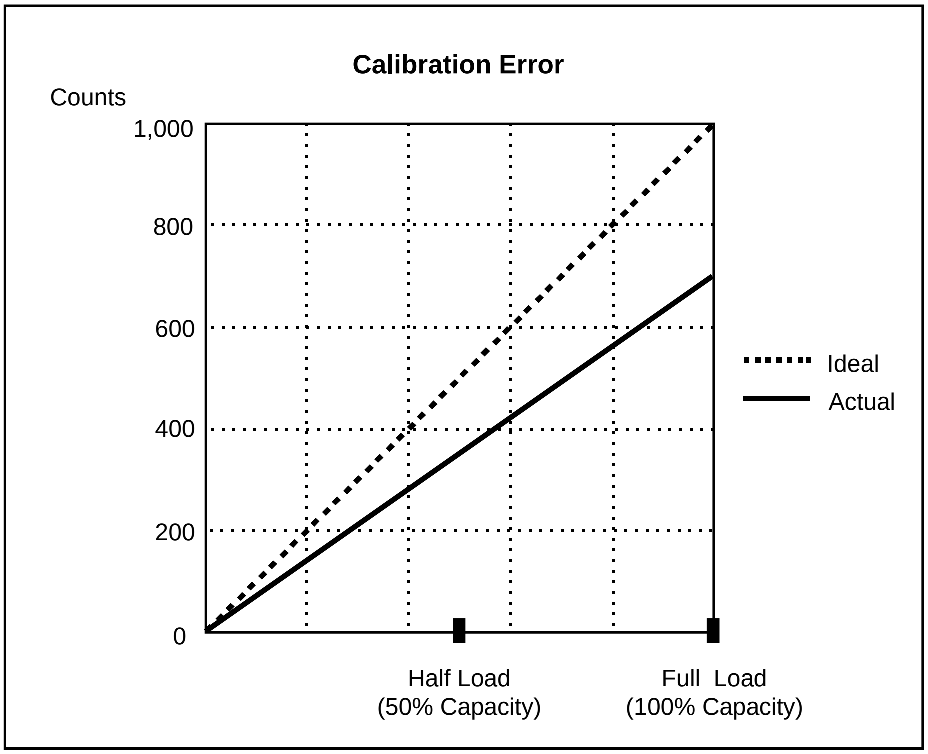


Figure 3-2: Calibration Error

Linearity Errors

Linearity is a scale's ability to maintain a consistent counts-to-load ratio (a straight line on the graph). When there is a linearity error, a scale reads correctly at zero and at full load capacity but incorrectly in between those two points (see Figure 3-3). The weight indication can either drift upward and read higher than the actual weight (as shown in the graph) or drift downward and read lower than the actual weight.

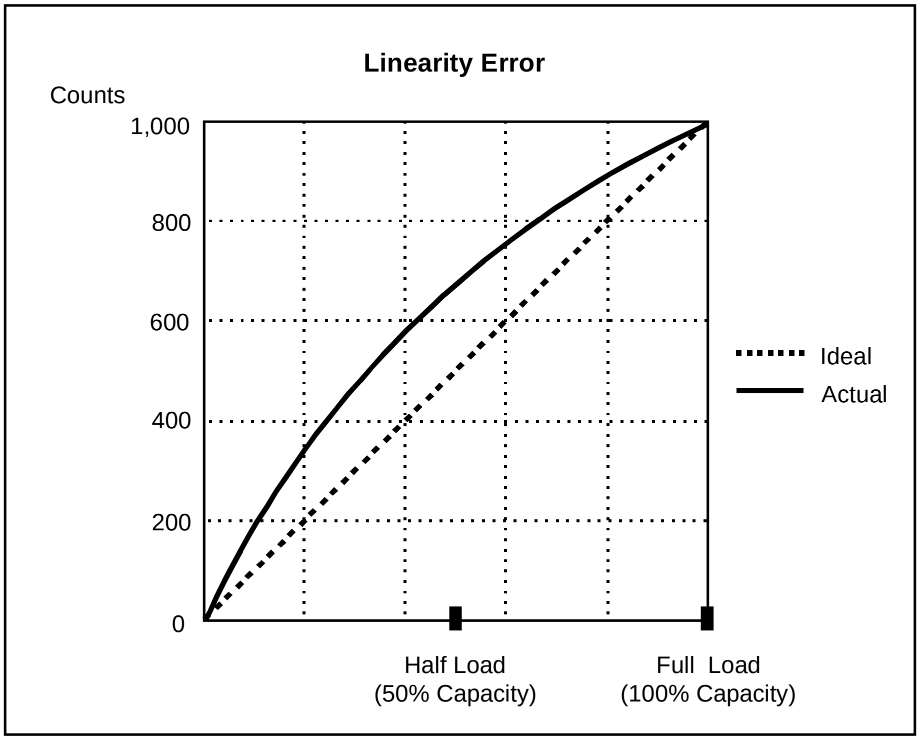


Figure 3-3: Linearity Error

Hysteresis Errors

Hysteresis is a scale's ability to repeat measurements as weights are added and removed. Figure 3-4 shows a typical hysteresis error. The scale is accurate at zero and at full load. When weight is gradually added to the scale, the curve drifts downward and the scale displays readings that are too low. When a load is placed on the scale and then the weight is gradually decreased, the curve drifts upward and displays readings that are too high. Hysteresis is measured from the actual linearity curves shown in the graph. It represents an energy loss and is a problem found only in electronic scales, not in mechanical scales. You should take steps to minimize linearity and hysteresis errors in batching, filling, and counting scale applications, especially when the full range of the scale is used. A scale can also display high readings when weight is added and low readings when weight is removed. But those errors would most likely be caused by creep or a mechanical problem, rather than by hysteresis.

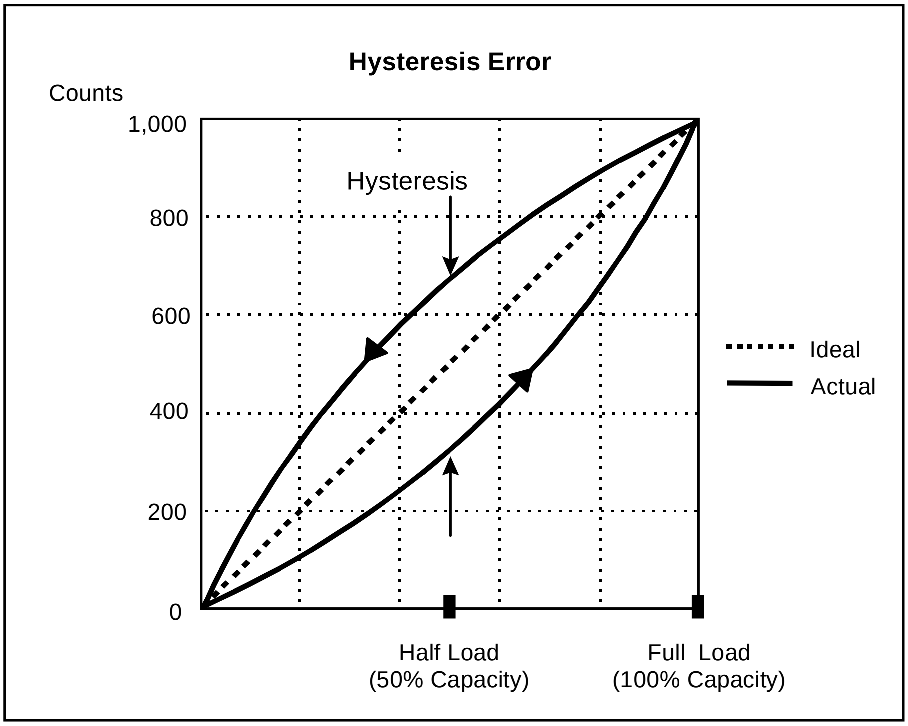


Figure 3-4: Hysteresis Error

Repeatability Errors

Repeatability is a scale's ability to repeat the same reading when a known weight is applied and removed several times. It is usually expressed as the maximum difference between any two readings taken in the same way and as a percentage of full load. For example, suppose the same 2,500-pound weight is placed on a 5,000-pound scale 100 times, with 2,501 being the highest reading and 2,500 being the lowest. The repeatability is 0.02% (1/5,000) of the scale's rated capacity (R.C.).

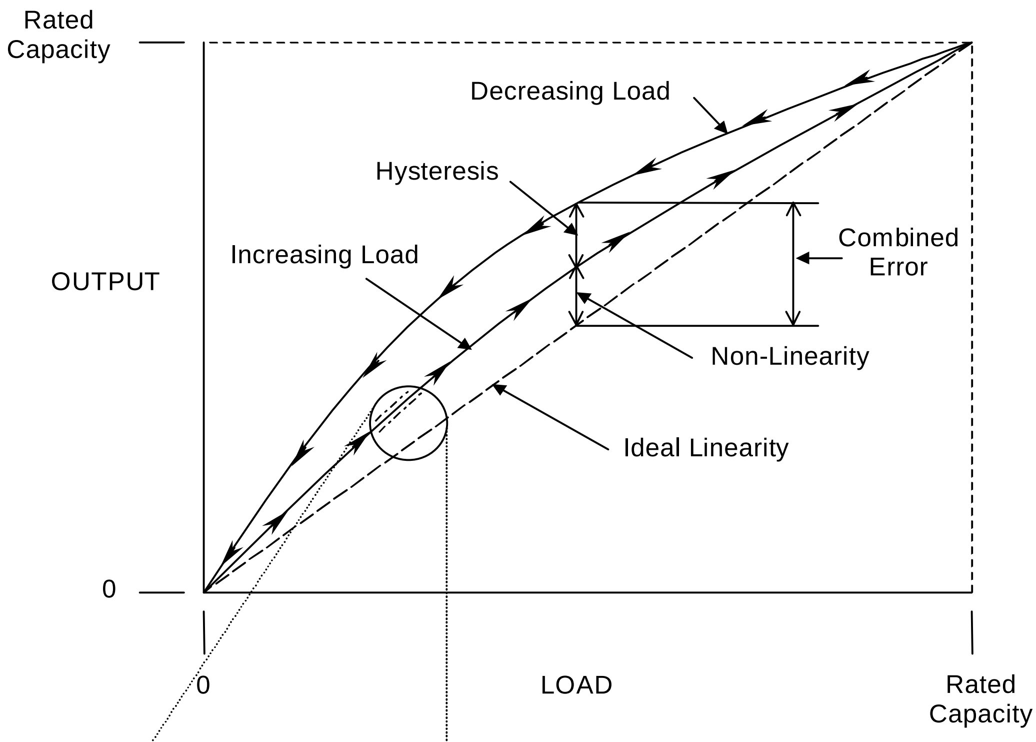
What Kind of Accuracy Can You Expect in the Real World?

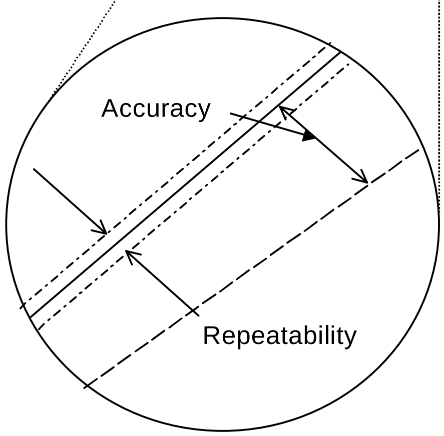
A scale is only as accurate as its load cells. The best you can expect from a scale is that it will approach the performance rating of the load cells alone. Here are typical performance ratings for a quality load cell:

- ± 0.01% R.C. non-linearity
- ± 0.02% R.C. hysteresis
- ± 0.03% R.C. combined error

Combined error for a sample load cell is shown in Figure 3-5 as an error band from zero to full capacity. All weight readings should fall within this error band. Under ideal conditions, a scale system's accuracy can approach the accuracy of the load cells alone (0.03% of system capacity). But in the real world, accuracy can be reduced by environmental and installation factors such as live-to-dead connections, piping, and the structural integrity of tank supports.

Actual system accuracy can be determined only by testing and validation after the system has been installed. Following the guidelines in this handbook will help you provide the most accurate weighing system possible for your application.





TYPICAL PERFORMANCE SPECIFICATIONS		
	Individual Load Cell	**Load Cell System**
Repeatability	0.01% RC*	0.03% FS**
Combined Error (Non-Linearity + Hysteresis)	0.03% RC*	0.10% FS**

* RC – Rated Capacity of load cell
**FS – Full Scale System Output, total of all load cells in system

Figure 3-5: Sample Load Cell System Performance Graph

Determining System Resolution

The ability of a combination of load cells and indicator to give the desired system resolution or increment size can be determined by the following formula:

$$\text{Signal Strength (Microvolts per Increment)} = \frac{\text{Desired Increment Size} \times \text{Load Cell Output (mV/V)}^{*} \times \text{Excitation Voltage}^{**} \times 1{,}000}{\text{Individual Load Cell Capacity} \times \text{Number of Load Cells}}$$

*Most METTLER TOLEDO load cells have an output of 2 mV/V.

**See Table 3-2 for excitation voltages.

Enter the desired increment size into the formula, along with the load cell and indicator parameters. If the signal strength (microvolts per increment) exceeds the minimum allowed for the indicator, the system should be able to deliver the desired resolution.

Indicator	Excitation Voltage	Minimum Microvolts per Increment (multiple cell)	Maximum Number of Displayed Increments
Jaguar®	15 VDC	0.1	100,000
Lynx®	15 VDC	0.1	50,000
Panther®	5 VDC	0.6	10,000
Puma® (Hazardous Area)	1.6 VDC	0.05	25,000

Table 3-2: Resolution Limitations for METTLER TOLEDO Indicators

Example

Suppose a tank scale has four 5,000-pound load cells (2 mV/V) attached to a Jaguar indicator. You want to be able to weigh up to 15,000 pounds at 2-pound increments (7,500 displayed increments). Use the formula to determine the required signal strength:

$$\frac{2\ \text{lb} \times 2\ \text{mV/V} \times 15\ \text{VDC} \times 1{,}000}{5{,}000\ \text{lb} \times 4} = 3.0\ \text{microvolts per increment}$$

According to Table 3-2, the minimum allowable signal strength for a Jaguar indicator is 0.1 microvolt per increment. Since the 3.0-microvolt signal derived from the formula is above this 0.1-microvolt minimum, you should be able to display 2-pound increments.

Industry Standards

There are several organizations that set standards for the scale industry and provide type evaluation to ensure the accuracy of scales. In the United States, type approval is given by the National Type Evaluation Program (NTEP), which is administered by the Office of Weights and Measures of the National Institute of Standards and Technology (NIST). In Europe, type approval is given by the European Economic Community (EEC) according to recommendations set by the Organisation Internationale de Métrologie Légale (OIML).

United States Standards

NIST is part of the United States Department of Commerce. It sponsors the National Conference on Weights and Measures (NCWM), an association of industry representatives and federal, state, and local officials. This organization adopts uniform laws and regulations recommended by NCWM members, and it publishes those regulations in NIST Handbook 44. Adopted by most states and localities, NIST Handbook 44 is the official listing of specifications, tolerances, and other technical requirements for weighing and measuring devices.

Type evaluation is the procedure used to test a particular type (or model) of weighing device. NTEP tests a sample of each model in a laboratory or in the field. If the model is produced in various sizes and capacities, NTEP will evaluate a selection of these based on the availability of sizes and capacities, the number of divisions, and the smallest division size. If the tests show that the scale(s) complies with the applicable technical requirements of NIST Handbook 44, NTEP issues a Certificate of Conformance for that model of scale.

A Certificate of Conformance indicates that the particular scale tested by NTEP met NIST Handbook 44 requirements, not that all scales produced meet the requirements. It is the scale manufacturer’s responsibility to make sure that every scale of a certified model meets the published specifications. Whether or not all models of an NTEP-certified scale conform to NIST Handbook 44 specifications is solely up to the discretion of the manufacturer. METTLER TOLEDO has procedural controls in place to guarantee that every scale is produced according to the same specifications.

NIST Handbook 44 defines both acceptance and maintenance tolerances. Acceptance tolerances must be met when the scale is first certified by NTEP. Maintenance tolerances are twice as large as acceptance tolerances and apply after the scale has been installed. Figure 3-6 shows NIST Handbook 44 acceptance tolerances for Class III scales.

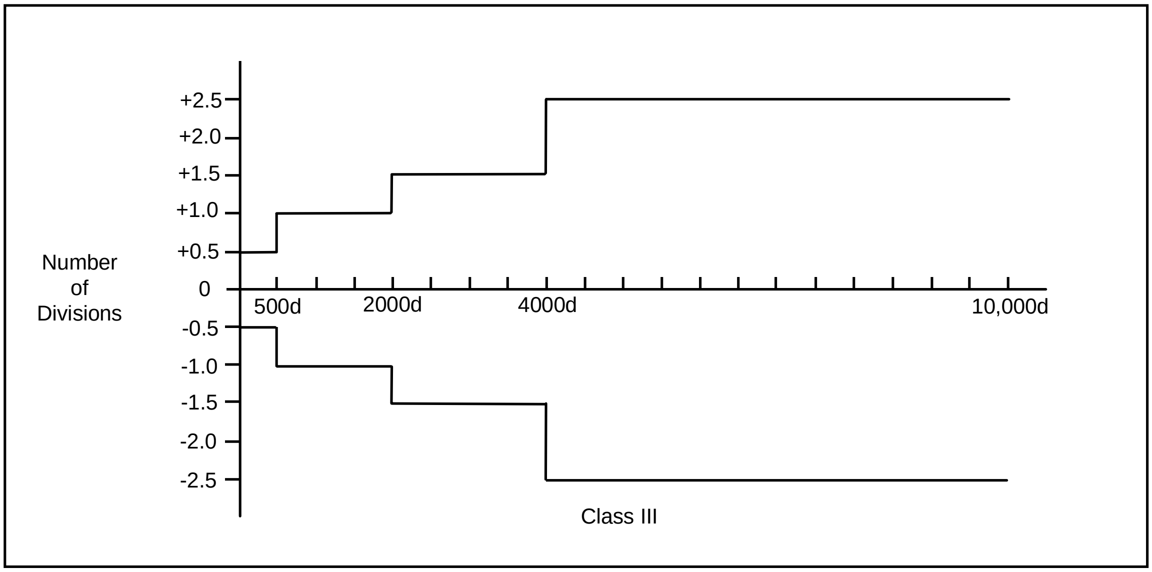


Figure 3-6: Handbook-44 Acceptance Tolerance Table

The divisions on the vertical axis represent permissible error (the specified limits). The horizontal axis shows the number of divisions that corresponds to the actual weight on the scale. For example, if a weight corresponding to 1,000 divisions is placed on the scale, the indicator must read 1,000 divisions, ±1.0 division. If the weight corresponds to 3,000 divisions, the tolerance is ±1.5 divisions. At full capacity, the tolerance is ±2.5 divisions. In order to be certified, a scale must perform within the specified limits over a temperature range of at least +10 to +40 degrees Celsius. Typically, scales are designed to perform within the specified limits over a larger temperature range (-10 to +40 degrees Celsius).

It is important to understand how tolerances relate to the accuracy of a scale. If a scale is rated as 5,000 divisions, that does not mean it is accurate to 1 part in 5,000. One part in 5,000 should never be used to express accuracy because, according to Handbook-44 tolerances, 2.5 parts of error are allowed at 5,000 divisions.

The accuracy of a scale can also be described as a percentage of applied load accuracy. In Figure 3-7 the dashed line indicates a performance of 0.1% of applied load accuracy, compared with Handbook-44 Class III acceptance tolerances. A 0.1% (or ±0.05%) applied load accuracy roughly corresponds with the NIST Handbook 44 chart through 5,000 divisions. Notice, however, that the line indicating 0.1% applied load accuracy falls outside the acceptance tolerance between 3,000 and 4,000 divisions and above 5,000 divisions. Because the 0.1% applied load accuracy method fails to meet tolerance standards at those points, it should be used only as an approximation of the acceptance tolerances. NIST Handbook 44 or local Weights and Measures guidelines should always be used as the actual acceptance tolerances.

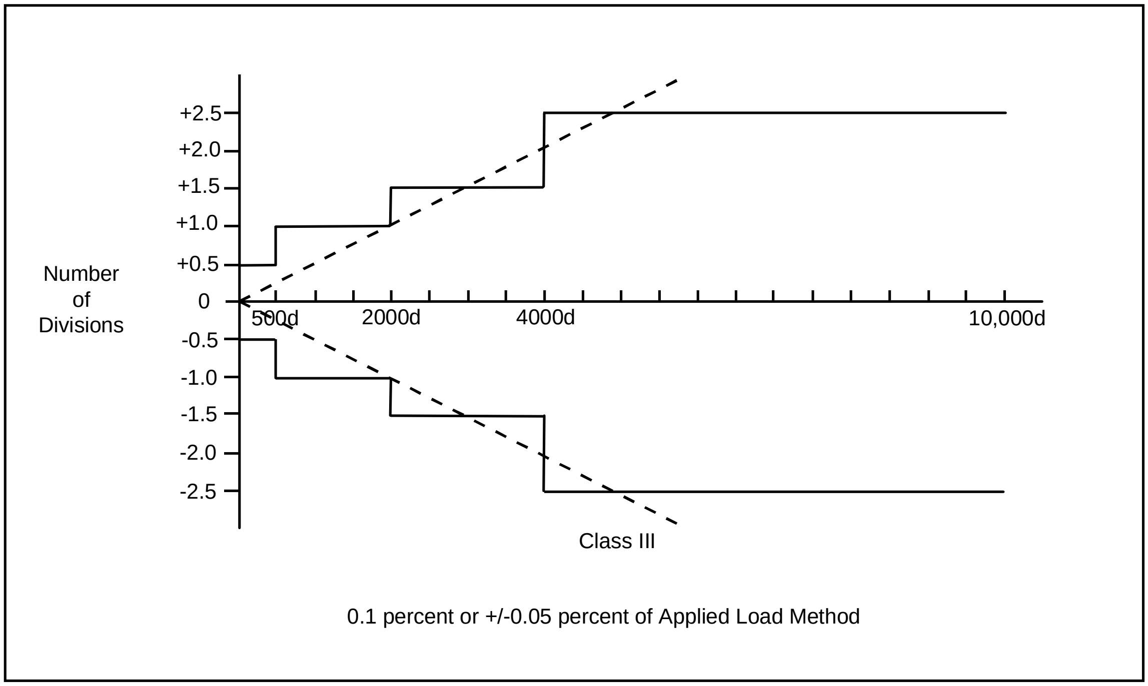


Figure 3-7: Handbook-44 Acceptance Tolerance Table (Percent Applied Load Method)

International Standards

Although NTEP certification is widely accepted in the United States, it is not a worldwide standard. When selling products outside of the United States, you should understand and follow the local standards. Some common standards include the Measurement Canada standard that is used in Canada and the Organisation Internationale de Métrologie Légale (OIML) standard adopted by the European Economic Community.

OIML is an independent international organization that develops standards for adoption by individual countries. Its main task is harmonizing the regulations and metrological controls applied by the national metrological services in the countries that are OIML members. There are two main types of OIML publications:

- **International Recommendations** (OIML R) are model regulations that establish the metrological requirements for scales, as well as requirements for specifying methods and equipment used to check a scale's conformity. OIML member countries are responsible for implementing the recommendations.
- **International Documents** (OIML D) provide information to help improve the work of the national metrological services.

A scale with NTEP certification does not automatically meet OIML standards. Several European testing labs (such as NMi, BTS, and PTB) conduct performance tests to verify whether the equipment meets OIML standards and is capable of performing its intended functions. OIML has its own set of accuracy classes and acceptance tolerances. Instruments are classified according to absolute and relative accuracy.

- Verification scale interval (e) represents absolute accuracy.
- Number of verification scale intervals (n = Max Capacity/e) represents relative accuracy.

The accuracy classes for instruments and their symbols are listed below:

Accuracy Class	Symbol
Special Accuracy	I
High Accuracy	II
Medium Accuracy	III
Ordinary Accuracy	IIII

Figure 3-8 shows OIML acceptance tolerances, and Figure 3-9 compares those with NIST Handbook 44 tolerances. Again, the vertical axis represents the permissible error and the horizontal axis represents the number of divisions that corresponds to the actual weight on the scale. Note that OIML acceptance tolerances are identical to those in NIST Handbook 44 from 0 to 4,000 divisions. At 4,000 divisions, the NIST acceptance tolerance increases from ±1.5 divisions to ±2.5 divisions, while the OIML acceptance tolerance remains at ±1.5 divisions up to 10,000 divisions.

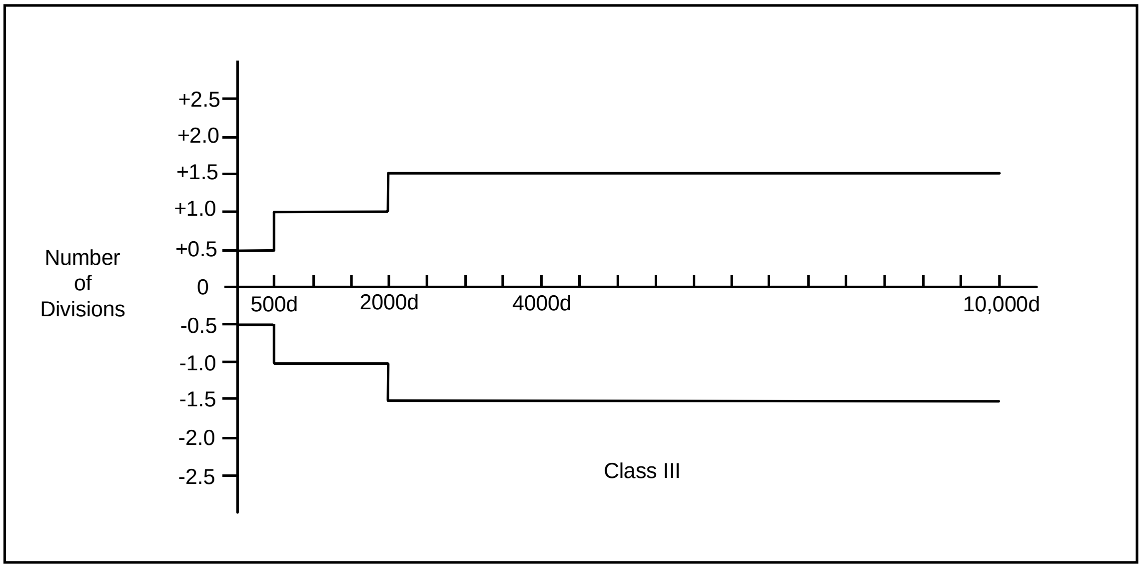


Figure 3-8: OIML Acceptance Tolerance Table

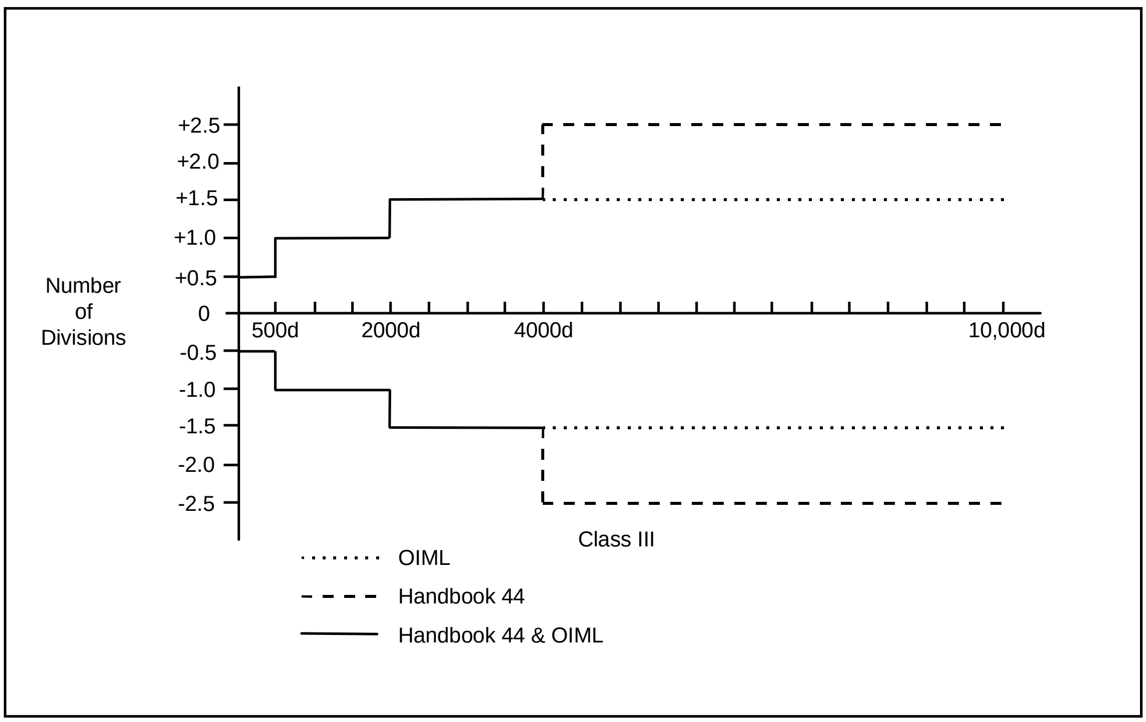


Figure 3-9: Handbook-44/OIML Acceptance Tolerance Overlay

In order be classified as "Legal for Trade," a scale must meet OIML acceptance tolerances. The scale's weight readings must be within the specified limits, relative to the number of divisions (or increments) that correspond to the actual weight used. For example, if a weight that corresponds to 5,000 divisions is placed on the scale, then the indicator must display 5,000 divisions ±1.5 divisions in order to meet OIML acceptance tolerances. In order for the same scale to meet NIST acceptance tolerances, the indicator could display 5,000 divisions ±2.5 divisions. The wider acceptance tolerance allowed by NIST was originally intended to approximate the 0.1% of applied load method.

The biggest difference between NIST and OIML, besides the units used (English and S.I. respectively), is the creep rate specification. Creep is the change in a weight reading when a weight is left on a scale over a period of time. NIST specifications allow a creep rate of 0.5 division for test loads of 0 to 500 divisions, 1.0 division for test loads of 500 to 2,000 divisions, 1.5 divisions for test loads of 2,000 to 4,000 divisions, and 2.5 divisions for test loads of 4,000 to 10,000 divisions when the load is applied for one hour. OIML standards allow a creep rate of 0.5 division for test loads equal to the scale capacity when the load is applied for 30 minutes. As you can see, for most capacities OIML standards are more stringent, allowing a smaller error over a shorter time period.

To meet OIML standards, a scale must satisfy all requirements and perform within the calibration tolerance limits.

Under EC Weights and Measures regulations, there is a difference between the concepts of a "test certificate" and an "approval." Approval is given only for entire scales (not for indicators or load cells alone). There are two types of approval:

- **EC Type Approval** for a self-contained complete scale.
- **EC "Umbrella" Approval** for a modular scale, made up of components (indicators, load cells, junction boxes, printers, etc.). Each component must have an EC Test Certificate, which must be listed on the umbrella approval.

Once an umbrella approval has been given, additional EC Test Certified components can be added to it later. The approval covers scale systems made up of various combinations of certified components. It also allows you to have one component approved while other components are still being developed.

4 Environmental Considerations

Because environmental factors can affect the accuracy and safety of a weigh module system, they must be considered during the design stage. If a scale will be subject to wind, seismic, or shock loading, you might need to use larger capacity weigh modules or add restraint devices so that the structure remains stable under extreme conditions.

Wind Loading

Wind loading can have a significant effect on outdoor weigh module applications. Because the potential for high winds varies from region to region, there is no one safety factor that can be used for all installations. When sizing weigh modules for an outdoor system, you should always factor in the local wind speed characteristics (see Figure 4.1). In extreme cases, you might need to add external restraints to keep high winds from tipping the tank.

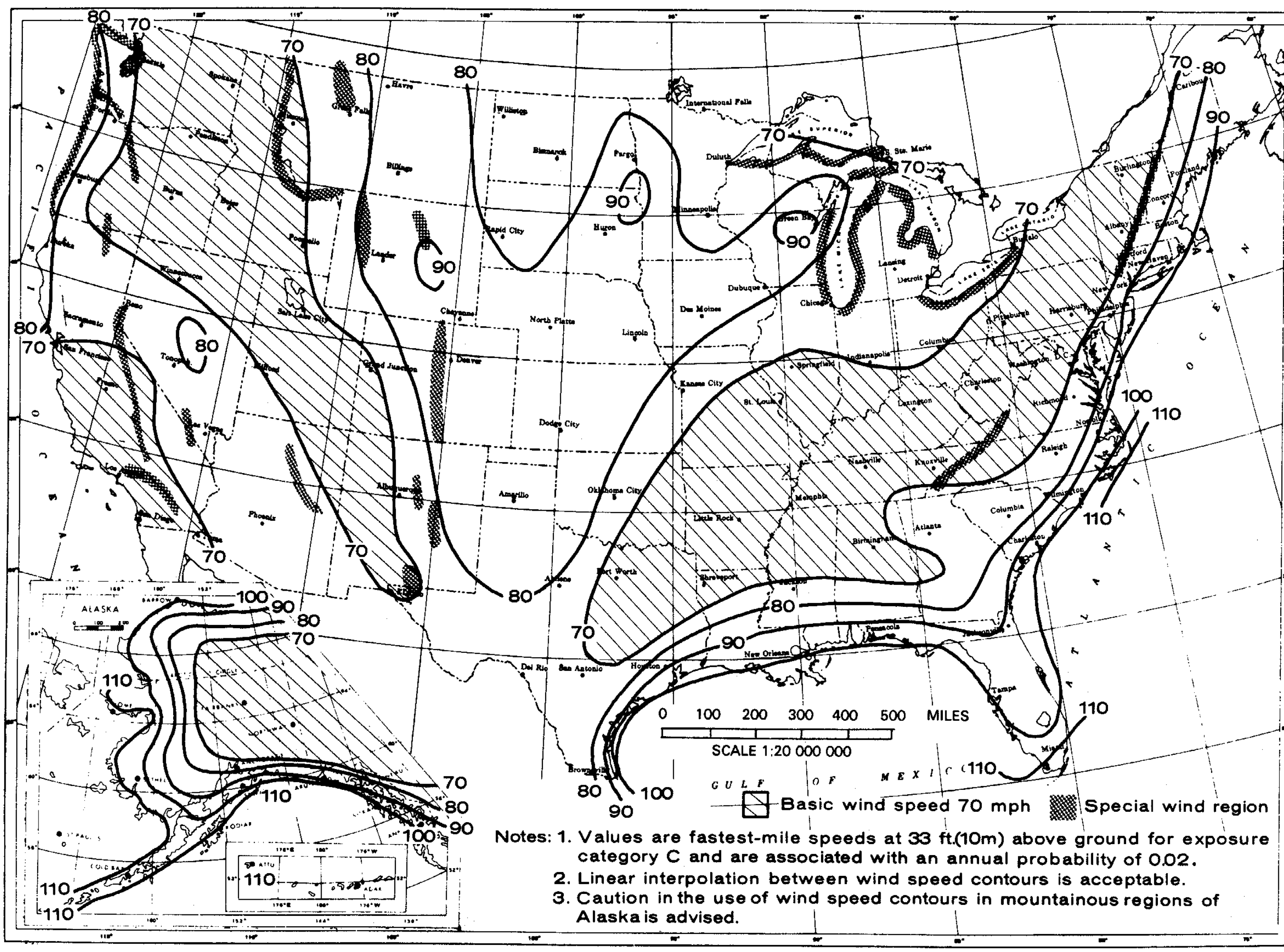


Figure 4-1: Wind Speed Characteristics for the United States

When wind exerts a simple horizontal force on one side of a tank, it creates a suction force on the opposite side of the tank. These combined forces work to tip the tank in the direction the wind is blowing. There are also right angle suction forces pulling on each side of the tank, but they tend to cancel each other out. The overall effect is that the wind exerts an uplift force on some load cells, a download force on other cells, and a shear force on all the cells.

You should determine wind loading for two scenarios: when a tank is empty and when it is full. The equation for calculating wind force is based on wind velocity, tank location, tank geometry, and accepted local standards and codes. Reaction forces (downward upward, and shear) should also be determined. The following information will be needed to calculate these forces:

- Gross Weight of the Tank (W_G)
- Empty Weight of the Tank (W_T)
- Diameter of the Tank (D)
- Height of the Tank's Legs (h_L)
- Height of the Tank (h_T)
- Number of Supports (N)
- Wind Velocity (V)
- Safety Factor (SF)

Reaction forces at the weigh modules are calculated via Statics (Equilibrium) based on the wind force at the center of gravity (c.g.) of the tank (see Figure 4-2). Methods for calculating reaction forces are covered in Appendix 4. Compare the reaction forces with the allowable loads for the weigh modules (see Appendix 5). You can then select weigh modules that are sized to accommodate both the weight of the full tank and the wind loading. It is possible that the load cells required to accommodate both the weight of the tank and wind loading could be large enough to compromise system resolution. If that is the case, consider adding external restraints to the weigh module system (see "Additional Vessel Restraint Methods" in Chapter 5) instead of using the larger load cells. For extra safety, construct wind breaks to shield the tank.

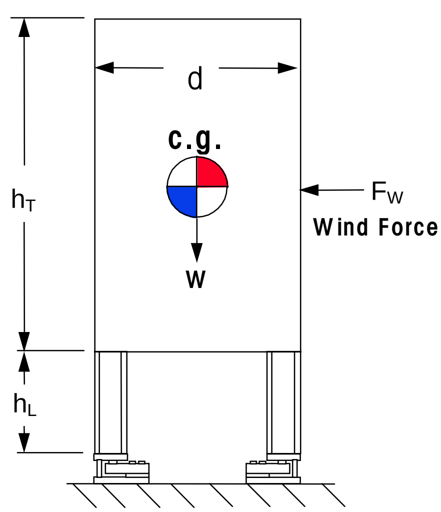


Figure 4-2: Tank Dimensions and Wind Force

Example

In the following example, we will calculate wind loading for a tank supported by four weigh modules and located on the coastline at Tampa, Florida. The wind force code used for this example is the *Ohio Basic Building Code* (BOCA). Always use the appropriate building code for your area to determine the equivalent wind force.

The installation has the following characteristics:

W_G = 30,000 pounds

W_T = 5,000 pounds

D = 8 feet

h_L = 4 feet

h_T = 20 feet

N = 4

SF = 1.25

To size weigh modules for this tank (assuming no wind force), multiply the gross weight of the full tank by a safety factor of 1.25:

$30{,}000 \times 1.25 = 37{,}500$

Then divide by the number of weigh modules to be used:

$37{,}500 \div 4 = 9{,}375$ *pounds per load cell*

To support 9,375 pounds, you would need a 10,000-pound weigh module. So without wind loading, the tank scale would use four 10,000-pound weigh modules.

Now calculate the wind force, using the following equation from the *Ohio Basic Building Code* (BOCA):

$F = P_V \times I \times K_Z \times G_H \times C_F \times A_F$

where:

P_V = 25.6 lb/ft^2 (V=100 mph); Basic Velocity Pressure [BOCA Table 1611.7(3)]

I = 1.10 (at hurricane oceanline); Importance Factor [BOCA Table 1611.5]

K_Z = 1.31 (Exposure Category D); Exposure Coefficient [BOCA Table 1611.7(4)]

G_H = 1.13 (Exposure Category D); Gust Response Factor [BOCA Table 1611.7(5)]

C_F = 0.74 [Table 16.11(4)]; Force Coefficient [BOCA Table 1611.9(1-5)]

A_F = 160 ft^2 (20 ft × 8 ft); Projected Area (normal to wind)

Calculation:

$F = 25.6 \times 1.10 \times 1.31 \times 1.13 \times 0.74 \times 160 = 4{,}936$

The maximum shear force exerted by the wind would be 4,936 pounds at the tank's center of gravity (see Figure 4-3).

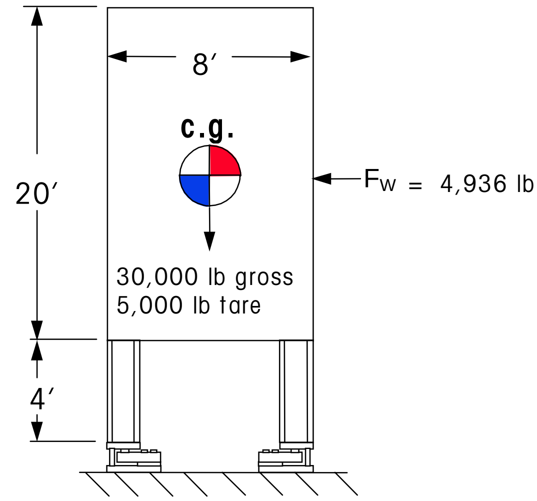


Figure 4-3: Wind Force Exerted on Sample Tank Scale

By using statics (see Appendix 4), we can calculate the maximum downward force and maximum uplift force:

- Maximum Shear Force: 4,936 pounds (equals wind force *F*)
- Maximum Downward Force: 16,138 pounds
- Maximum Uplift Force: 7,388 pounds

Compare these forces with the load ratings chart in Appendix 5. Note that they exceed the allowable loads for 10,000-pound weigh modules. To accommodate wind forces for this tank, you will need to use four 20,000-pound weigh modules or add external check rods that are strong enough to handle the additional force (see Chapter 5).

Alternative Method

The following equation provides a generic method for determining resultant wind force:

$$F_W = 0.00256 \times V^2 \times h_T \times d \times S$$

where:

F_W = Resulting Wind Force (pounds)

V^2 = Wind Velocity Squared (mph)

h_T = Height of the Tank (feet)

d = Diameter of the Tank (feet)

S = Shape Factor:

Circular Tanks = 0.6

Hexagonal or Octagonal Tanks = 0.8

Square or Rectangular Tanks = 1.0

F_W will be the horizontal force applied at the tank's center of gravity. Use statics to determine the resulting reaction forces at the supports, and compare the results with the allowable load ratings to size the weigh modules.

Seismic Loading

Seismic forces, movement caused by earthquakes and other shifts of the earth, are among the strongest external forces that can affect a tank scale. Figure 4-4 shows seismic potential for the United States, with seismic zone 0 being the least likely location for an earthquake and seismic zone 4 the most likely location for an earthquake.

Seismic forces are analyzed in much the same way as wind forces. An equivalent horizontal shear force (F_{EQ}) is determined by using the appropriate formulas from the governing building code. Formulas referenced in this section are from the *1988 Uniform Building Code* (UBC) as adopted by the State of California, a state with a high risk of seismic activity.

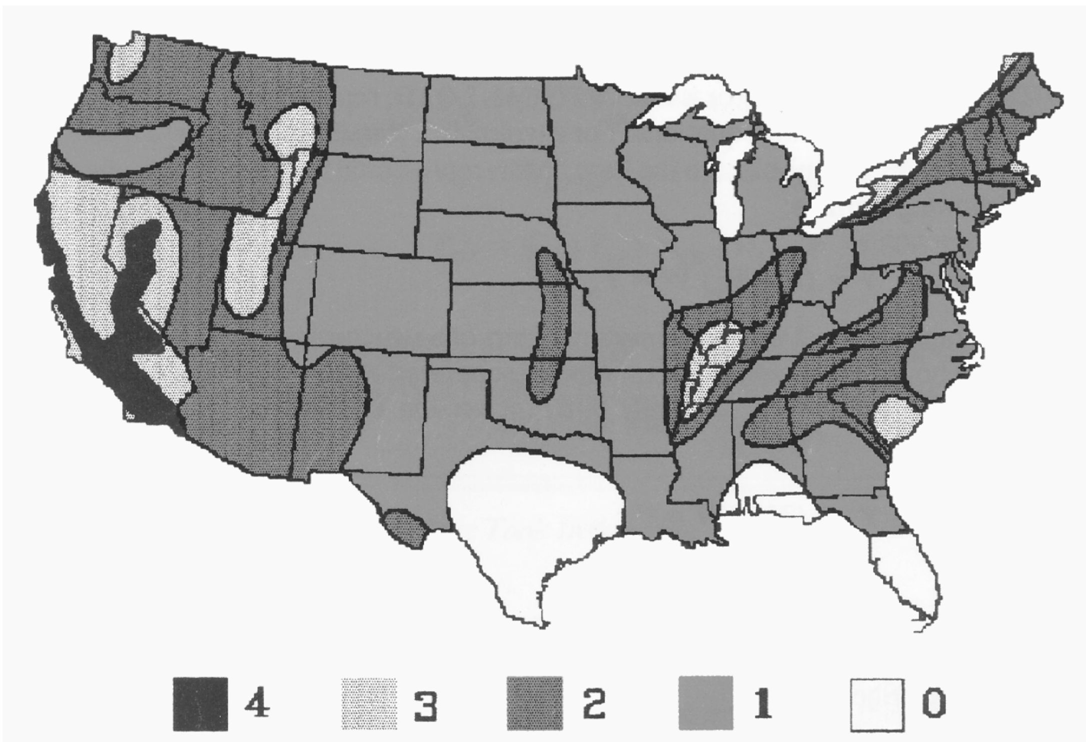


Figure 4-4: Seismic Zones in the United States

UBC Code Formulas

The following UBC Code formulas are used to determine horizontal shear force (F_{EQ}) for free-standing tanks and for tanks that are part of a structure:

$V = (ZIC/R_w)W = F_{EQ}$ for free-standing tanks

$F_P = (ZIC_P)W = F_{EQ}$ for tanks that are part of a structure

where:

V = Base Shear

F_P = Periodic Force

Z = Seismic Zone Factor

Zone 4: 0.40
Zone 3: 0.30
Zone 2B: 0.20

Zone 2A: 0.15

Zone 1: 0.10

I = Importance Factor

Nonhazardous materials: 1.00

Hazardous materials: 1.25 to 1.50

C = Lateral Force Coefficient: 2.75 for most conditions

C_P = Lateral Force Coefficient (Tank as part of structure)

Nonhazardous materials: 0.75

Hazardous materials: 1.25

Vessels on roof of building: 2.00

R_W = Numerical Coefficient from Tables 23-O and 23-Q of UBC

Bins & Hoppers: 4.00

Tanks: 3.00

F_{EQ} Factors Based on UBC Code

Table 4-1 provides a simpler way to determine horizontal shear force (F_{EQ}). The factors listed in the table are based on the UBC Code formulas presented above.

	Nonhazardous	Hazardous	
		Conservative	Nonconservative
Free-Standing Bin/Hopper			
Zone 4	0.28	0.41	0.34
Zone 3	0.21	0.31	0.26
Zone 2B	0.14	0.21	0.17
Zone 2A	0.10	0.15	0.13
Zone 1	0.07	0.10	0.09
Free-Standing Tank			
Zone 4	0.37	0.55	0.46
Zone 3	0.28	0.41	0.34
Zone 2B	0.18	0.28	0.23
Zone 2A	0.14	0.21	0.17
Zone 1	0.09	0.14	0.11
Structural Bin/Hopper/Tank			
Zone 4	0.30	0.75	0.63
Zone 3	0.23	0.56	0.47
Zone 2B	0.15	0.38	0.31
Zone 2A	0.11	0.28	0.23
Zone 1	0.08	0.19	0.16
Roof-Mounted Bin/Hopper/Tank			
Zone 4	0.80	1.20	1.00
Zone 3	0.60	0.90	0.75
Zone 2B	0.40	0.60	0.50
Zone 2A	0.30	0.45	0.38
Zone 1	0.20	0.30	0.25

Table 4-1: Horizontal Shear Force Factors (F_{EQ}) Based on UBC Code

Find your application in the table, based on tank location, tank contents, and seismic zone. Multiply the corresponding factor by the gross weight of the tank or vessel. The resulting value will equal the horizontal shear force (F_{EQ}) applied at the tank's center of gravity (see Figure 4-5).

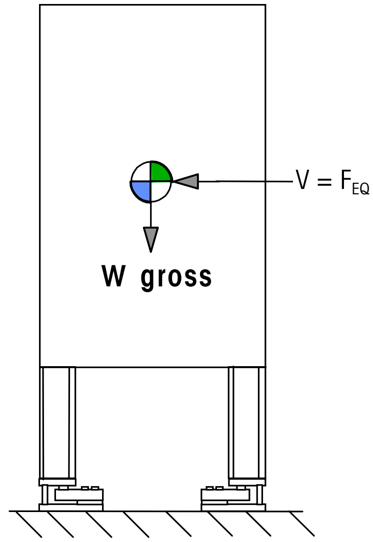


Figure 4-5: Horizontal Shear Force Applied to Tank

Reaction forces at the weigh modules are determined using Statics (see Appendix 4) based on the shear force (F_{EQ}) applied at the tank's center of gravity. Compare the reaction forces with the allowable loads for the weigh modules (see Appendix 5). The weigh modules can then be sized to accommodate the resulting seismic loads, or external checking can be added as needed to counter seismic loads.

Shock Loading

Shock loading can affect a scale's design, especially for conveyor applications or floor scale conversions. It is caused by an abrupt change in the weight placed on a scale, for example, when an object is dropped on the scale. If shock forces are strong enough, you will need to install higher capacity load cells. To estimate a shock force, you must know the weight of the object being dropped, the vertical distance it is dropped, and the empty weight of the scale structure. You must also know the spring rate of the nominal load cell capacity. The spring rate constant for a load cell is its rated capacity divided by load cell deflection at rated capacity. For crane loading applications, you need to know the crane's rate of descent.

Determine the nominal load cell capacity by multiplying the scale's gross capacity by 1.25 and then dividing by the number of supports. Then use one of the following equations to estimate the shock forces caused by dropped or lowered weights.

Equation for Dropped Weight:

$$F_{MAX} = W_2 + W_1 \left[1 + \sqrt{1 + \frac{2KH}{W_1 + W_2}} \right]$$

Equation for Lowered Weight:

$$F_{MAX} = W_2 + W_1 \left[1 + \sqrt{1 + \frac{K (W_1 + W_2) V^2}{GW_1^{\ 2}}} \right]$$

Where:

F_{MAX} = Shock Force (pounds)

W_1 = Weight being Dropped or Lowered (pounds)

W_2 = Dead Weight of Platform (pounds)

K = Spring Rate of Load Cells (pounds/inch), see Table 4-2

V = Velocity at which Object is Lowered (inches/second)

G = Gravity (384 inches/second^2)

H = Height from which Object is Dropped (inches)

Load Cell Capacity	Spring Rate (K)
250 lb	17,857
500 lb	50,000
1,250 lb	125,000
2,500 lb	250,000
5,000 lb	416,667
10,000 lb	833,333
20,000 lb	555,556
30,000 lb	833,333
45,000 lb	692,308
50,000 lb	1,666,667
75,000 lb	1,500,000
100,000 lb	3,333,333
150,000 lb	5,000,000
200,000 lb	6,666,666

Table 4-2: Nominal Spring Rates for METTLER TOLEDO Load Cells

Once you have calculated the shock force for a scale, determine how that force will be distributed over the load cells. If an object is dropped in the center of a four-module scale platform, the shock force will probably affect all four load cells equally. If it is dropped on one side of the platform, the shock force could be concentrated on two load cells. To estimate the shock loading per load cell, divide the shock force by the number of load cells it will be concentrated on. Then compare that shock loading with the allowable download ratings per weigh module listed in Appendix 5. If the shock loading is too large for the nominal load cell capacity, you will need to use higher capacity weigh modules.

Instead of increasing weigh module capacities, you might consider one of the following ways to reduce the shock loading:

- Place objects onto the scale without dropping them.

- Add mass to the scale platform.
- Use a shock-absorbing material such as (1) Fabreeka® pads, (2) coil springs, (3) railroad ties, or (4) build a sandbox (foundry).

(Fabreeka is a registered trademark of Fabreeka International, Inc.)

Vibration

If a scale vibrates constantly, it might not come to rest long enough to capture an accurate weight reading. METTLER TOLEDO indicators have built-in filtering systems that can eliminate most of the effects of vibration. When installing a weigh module system, you should take steps to reduce any external or internal vibration that the indicator cannot eliminate.

External Vibration: A scale can be affected by vibration from its foundation or from the surrounding environment. We recommend finding the source of the vibration and correcting it to eliminate its effect on the scale. Cutting the floor slab or separating the scale support frame from surrounding structures can also prevent external vibration from affecting a scale's stability.

Internal Vibration: Vibrations produced inside a tank are normally caused by sloshing liquid or agitation. In large tanks, sloshing can produce low-frequency vibrations that are difficult to eliminate at the scale indicator. You can reduce sloshing by installing baffles in a tank. If an agitator and its drive motor are permanently attached to a scale, you might need to incorporate isolation pads (such as Fabreeka®, available from METTLER TOLEDO) in the mounting of the weigh modules to minimize the internal vibration. To improve weighing accuracy, make sure the agitator is stopped while weight readings are taken.

It is difficult to analyze the effects of vibration that is caused by wind. If high accuracy is required, we recommend shielding the scale from wind. Any time a tank is located outdoors, it should be designed to minimize vertical forces resulting from wind.

Temperature Effects

Temperature can affect a weigh module system by causing structural supports to expand and contract or by exceeding the operating limits of the strain-gauge load cells. As a tank expands and contracts, it pushes or pulls on attached piping. If the piping connections are rigid, this can cause weighing errors. The following equation can be used to calculate the change in the length of a tank as the temperature changes:

$$\Delta L = a \times L \times \Delta T$$

Where:

ΔL = Change in Length

a = Coefficient of Linear Expansion

L = Original Length

ΔT = Change in Temperature

Table 4-3 lists temperature specifications for METTLER TOLEDO load cells. The compensated range is the temperature range in which the load cell will meet or exceed

NIST Handbook 44 legal-for-trade tolerances. The service/storage range is the temperature range in which the load cell will operate without physical damage.

METTLER TOLEDO Load Cells	
Compensated Range	-10°C to +40°C (+14°F to +104°F)
Service/Storage Range	-50°C to +85°C (-58°F to +185°F)

Table 4-3: Load Cell Temperature Specifications

In applications with high temperatures inside the tank, you can reduce thermal conduction by placing insulation between the tank and the weigh modules. Use insulating material with a compressive strength above 15,000 psi and thermal conductivity ratings below 2.0 BTU-in/ft^2/hr. The material must be able to withstand the exposure temperature for prolonged periods without breaking down or deforming. Two recommended FDA-approved materials are listed below:

Acetron® GP Acetal (Acetron is a registered trademark of DSM)

- Continuous Service Temperature: 180°F
- Heat Deflection Temperature at 264 psi: 220°F
- Thermal Conductivity: 1.6 BTU inches/hour/$foot^2$/°F
- Coefficient of Thermal Linear Expansion: 5.4×10^{-5}
- Compressive Strength: 15,000 psi

Ultem 1000 Polyetherimide (PEI)

- Continuous Service Temperature: 340°F
- Heat Deflection Temperature at 264 psi: 392°F
- Thermal Conductivity: 0.9 BTU inches/hour/$foot^2$/°F
- Coefficient of Thermal Linear Expansion: 3.1×10^{-5}
- Compressive Strength: 22,000 psi

Moisture and Corrosion

Moisture or corrosive material on a weigh module can affect the life of the load cells. Debris, such as leaves and dirt, accumulated in and around weigh modules can also cause problems. There are several steps you can take to minimize the potential for moisture and corrosion problems:

- Provide adequate drainage away from the weigh modules.
- Keep weigh modules clear of snow that will melt and introduce moisture into the system.
- Do not use tanks with flat tops that catch and retain water, snow, leaves, or other debris that will add uncompensated weight to the system.
- Hose down the tanks regularly to clean accumulated debris.
- Keep cables clean and in good condition. Broken cables or worn cable sheathing can allow water to enter and cause corrosion.

- Protect cables by placing them in conduit or teflon wrap.
- Locate tanks (and weigh modules) away from corrosive materials and chemicals. The combined effects of temperature, water, and air can corrode nearby weigh modules. If tanks are near corrosive substances, provide protective coatings and shieldings. Positive air flow in the area can also help prevent corrosion damage.
- Store tools, supplies, and trash away from the tank and weighing system.

NEMA/IP classifications for electrical equipment enclosures are covered in Appendix 10. A chemical resistance chart is provided in Appendix 12.

Lightning and Surge Protection

Lightning protection devices should be installed to protect a scale from being damaged by lightning. Use devices that are designed to keep the current produced by lightning from reaching ground through the load cell. Instead, the devices should provide a low-resistance alternative path to ground near each weigh module (see Figure 4-6).

- Verify the integrity of any existing grounding systems.
- Use a single-point grounding system.

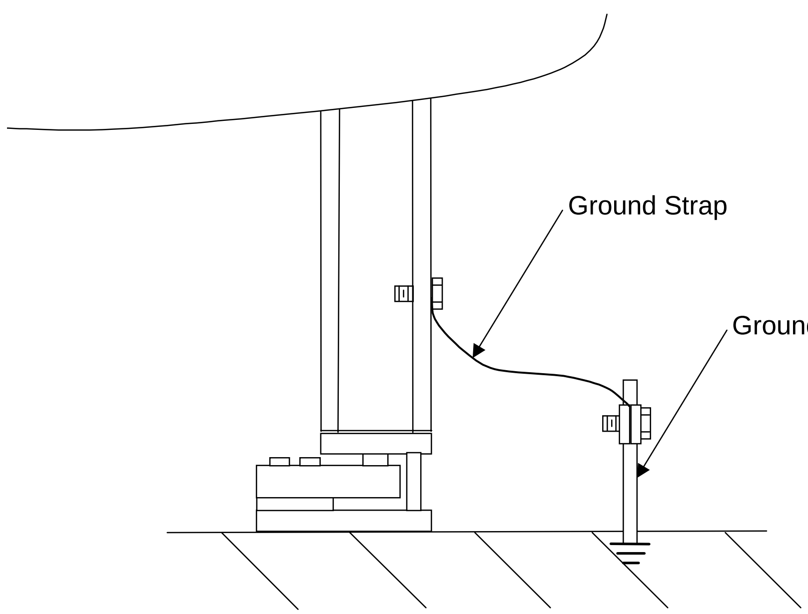


Figure 4-6: Grounding System for a Weigh Module

Surges are brief changes in voltage or current. They can be caused by lightning or by equipment with large motor loads (HVAC systems, variable-speed motors, etc.). Minor power surges can be eliminated by using an Uninterruptable Power Supply (UPS) or Power Conditioner. You should provide surge protection to prevent damage to a weigh module system.

5 General Installation Guidelines

Applying Force to Load Cells

Load cells that use strain gauges are sensitive enough to detect very small changes in weight. The trick is to make sure that they react only to the weight you want to measure, not to other forces. To get accurate weight readings, you must carefully control how and where weight is applied to a load cell. Ideally, a load cell should be installed so that the load is applied vertically throughout the entire weight range (see Figure 5-1).

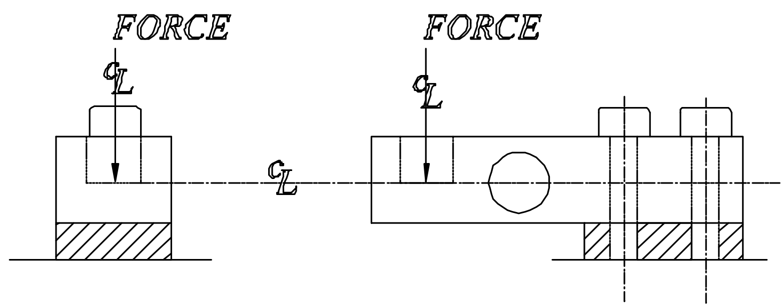


Figure 5-1: Ideal Loading (Entire Force Applied Vertically)

To attain that ideal, the weigh vessel and load cell support would need to be level, parallel, and infinitely rigid. When a tank scale and its structural supports are designed and installed carefully, it is possible for the scale to approach an ideal loading application. When a scale is not installed properly, there are several types of forces that can affect its accuracy. The following sections describe loading problems commonly encountered in tank scale applications.

Angular Loading

Angular loading occurs when a force that is not perfectly vertical is applied to a load cell. This diagonal force can be defined as the sum of its vertical component and its horizontal component. In a well-designed weigh module application, the load cell will sense the weight (vertical force) but will not sense the side load (horizontal force).

Figure 5-2a and Figure 5-2b show a weigh module application with the load cell anchored to a foundation. In Figure 5-2a, the force exerted by the tank's weight is perfectly vertical. In Figure 5-2b, the force is applied at an angle. The vertical component (*F*) of this angular force is normal to and sensed by the load cell; it is equal to the force applied in Figure 5-2a. The horizontal component (side load) = *F ´ Tangent q*.

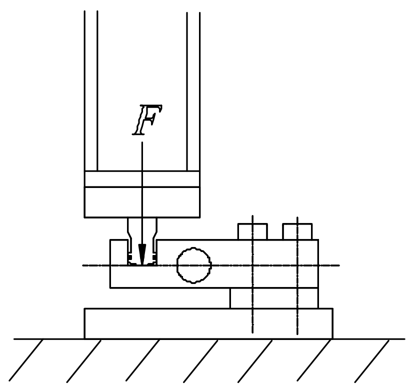


Figure 5-2a: Vertical Force

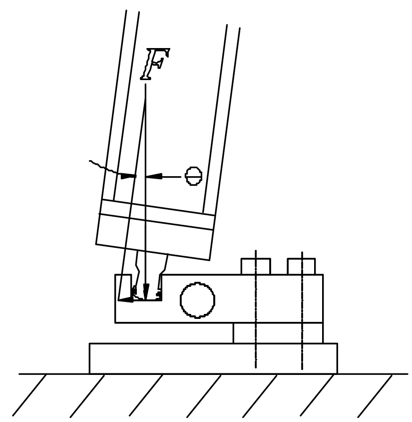


Figure 5-2b: Angular Force

Figure 5-3a and Figure 5-3b show how angular loading would affect a load cell anchored to the tank that is being weighed. Figure 5-3a shows an ideal installation with a perfectly vertical force. In Figure 5-3b, the force (F_N) that is normal to and sensed by the load cell would be less than the vertical force (*F*) applied to the load cell in the ideal installation. In this case, F_N = *F ´ Cosine q*.

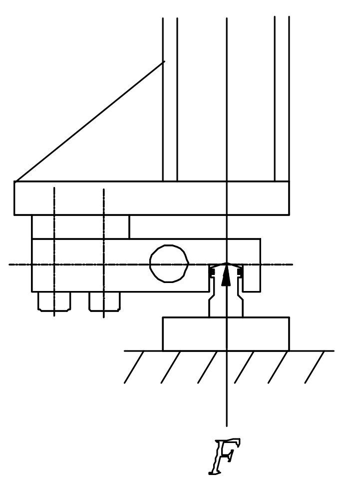


Figure 5-3a: Vertical Force

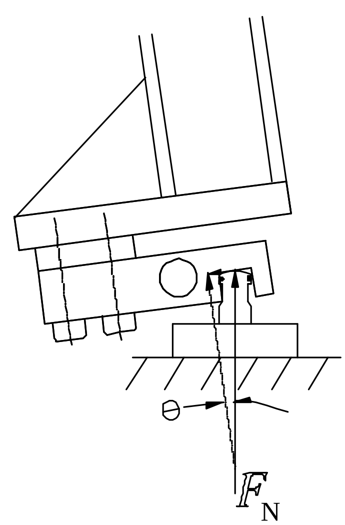


Figure 5-3b: Angular Force

Eccentric Loading

Eccentric loading occurs when a vertical force is applied to a load cell at a point other than its center line (see Figure 5-4). This problem can be caused by thermal expansion and contraction or by poorly designed mounting hardware. You can avoid eccentric loading problems by using a weigh module system that will compensate for expansion and contraction.

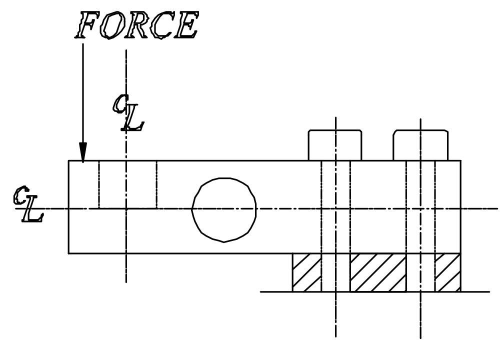


Figure 5-4: Eccentric Loading

Side and End Loading

Side and end loading occur when horizontal forces are applied to the side or end of a load cell (see Figure 5-5). They can be caused by thermal expansion and contraction, by misalignment, or by vessel movement due to dynamic loading. Side and end forces can affect the linearity and hysteresis of the scale. For static loading applications, use a weigh module system that compensates for thermal movement. For dynamic loading applications, use a weigh module system with a self-aligning load pin suspension.

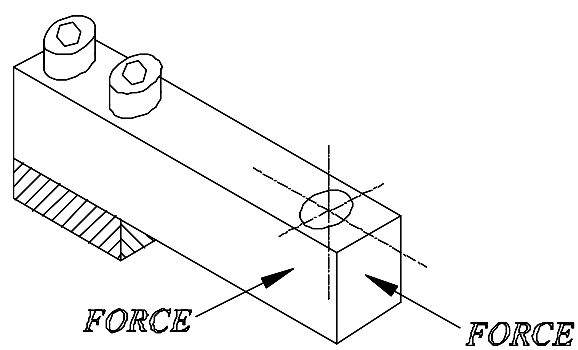


Figure 5-5: Side and End Forces Applied to a Load Cell

Torsional Loading

Torsional loading occurs when a side force twists a load cell (see Figure 5-6). It can be caused by structural deflection, system dynamics, thermal movement, or mounting hardware misalignment. Torsional loading will reduce a system's accuracy and repeatability. To avoid this problem, always follow proper structural support and installation guidelines, and use weigh modules that compensate for tank movement.

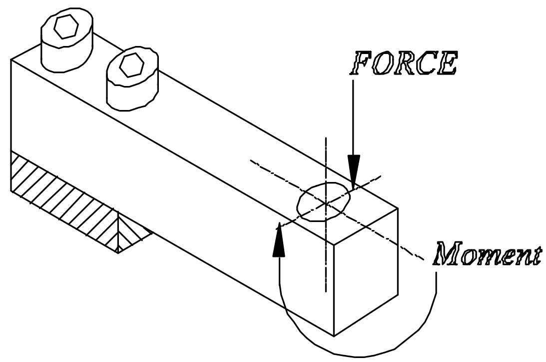


Figure 5-6: Torsional Loading Applied to a Load Cell

Tank and Vessel Design

The accuracy of a tank scale can be affected by the design of the tank itself. A new tank should be designed so that it will not deflect significantly under the weight of its contents and will not be subject to pressure imbalances when it is filled or emptied. If you are converting an existing tank to a scale, you might need to modify the tank to meet these requirements.

Structural Integrity

A tank, like its support structure, can deflect under the weight of its contents. This is a special concern if the tank has a large diameter or if the legs are long and tend to bow (see Figure 5-10a). Flexmount weigh modules are designed to compensate for minor tank deflection. But serious tank deflection (more than 0.5 degree from level) will cause linearity errors and inaccurate weighments. The design engineer is responsible for making sure that tank deflection is within specification. Excessive deflection can be corrected by bracing the tank's legs or connecting them together (see Figure 5-10b).

Pressure Imbalances

When a material flows rapidly into or out of an unvented tank, it can create a pressure imbalance. If a tank is being filled, the air pressure inside the tank would be greater than the pressure of the air surrounding the tank. For example, suppose 500 cubic feet of liquid from a pressurized pipeline is added to a tank. The liquid would displace 500 cubic feet of air inside the tank. Unless that 500 cubic feet of air is vented, pressure will build up inside the tank. The increased pressure will produce a weighing error until a pressure balance can be restored. A similar condition occurs when a material is discharged rapidly from a tank, creating a partial vacuum inside the tank. To prevent pressure imbalances, make sure that the tank is adequately vented. That will allow you to weigh the contents accurately as soon as the tank is filled or emptied, instead of having to wait for a pressure balance to be restored. Vents should be vertical and provided with clean-out doors and fume stops or dust collectors.

Provisions for Test Weights

If you are going to use test weights to calibrate a tank scale, you will need some way to hang the test weights from the tank. In most cases, this can be done with some type of mounting lugs spaced evenly around the tank. Figure 5-7 shows a mounting lug with a test weight hanging from it. Use a hoist for raising/lowering the weight.

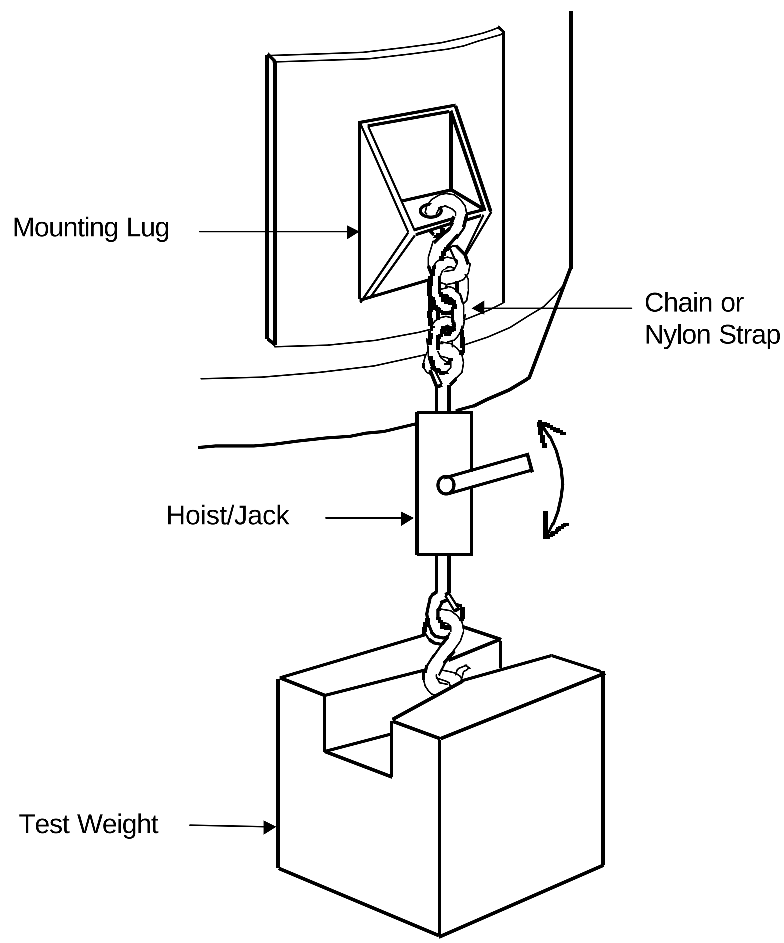


Figure 5-7: Mounting Lugs for Test Weight

Structural Support Guidelines

The following guidelines provide information that can help you install a scale's structural supports properly.

Support Deflection

Because load cells deflect only about 0.01 to 0.03 inch at rated capacity, they must be sensitive to very small movements. Even deflections in a tank scale's structural support system can affect the weight indicated by the scale. Excessive or non-uniform deflection will introduce unwanted non-vertical forces at the load cells, reducing a system's accuracy and repeatability. When designing a weigh module support structure, you should follow these three guidelines:

- The support brackets for the weigh modules should not deflect more than 1/2 degree out of level at full capacity.
- The base support structure for the weigh modules should not twist or deflect more than 1/2 degree out of level at full capacity.
- The base support structure for the weigh modules should deflect uniformly.

The following three figures show how support deflection affects a weigh module.

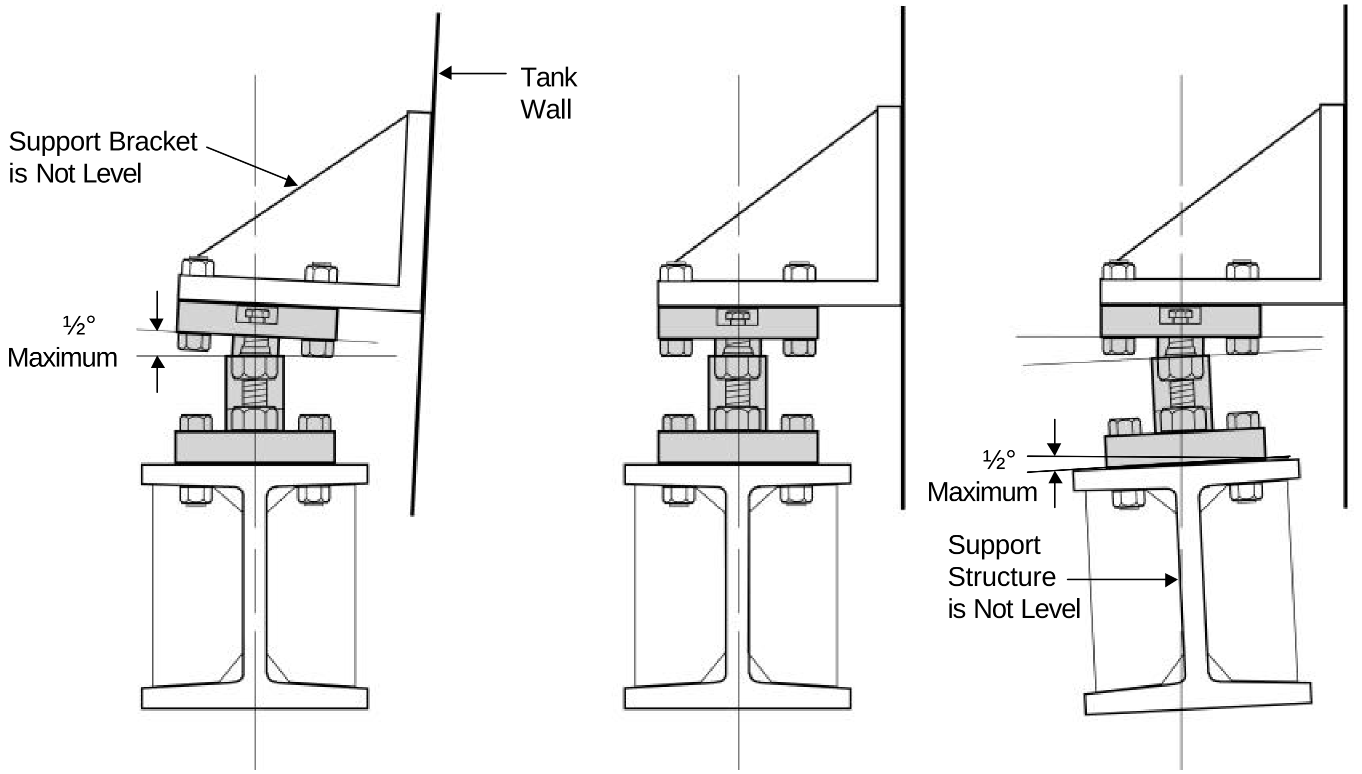


Figure 5-8a Figure 5-8b Figure 5-8c

- Figure 5-8a: Support bracket is out of level, applying side forces to the load cell.
- Figure 5-8b: Support bracket and support structure are aligned properly.

- Figure 5-8c: Support structure is out of level, applying side forces to the load cell.

A tank scale's support structure should deflect as little as possible, and any deflection should be uniform at all support points (see Figure 5-9). Excessive deflection can cause inlet and outlet piping to bind, creating linearity errors. When deflection is not uniform, it can cause repeatability errors and zero return errors due to creep.

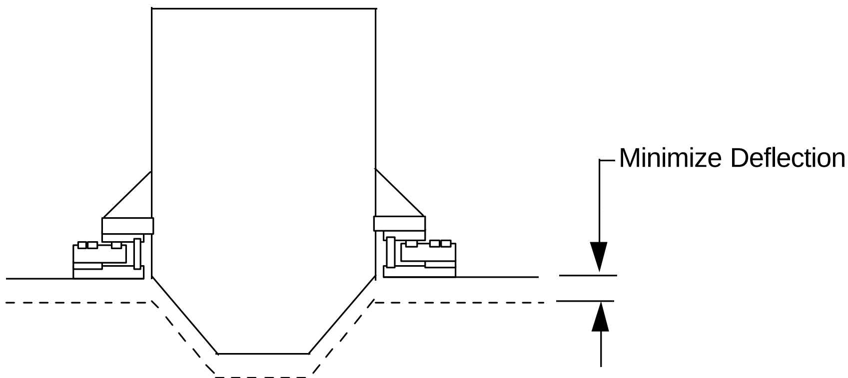


Figure 5-9: Weigh Module Base Support Structure Deflection

In some cases, a tank's legs will deflect under the weight of the tank (see Figure 5-10a). If the deflection is great enough to affect weight readings, you should brace the legs to keep them rigid (see Figure 5-10b).

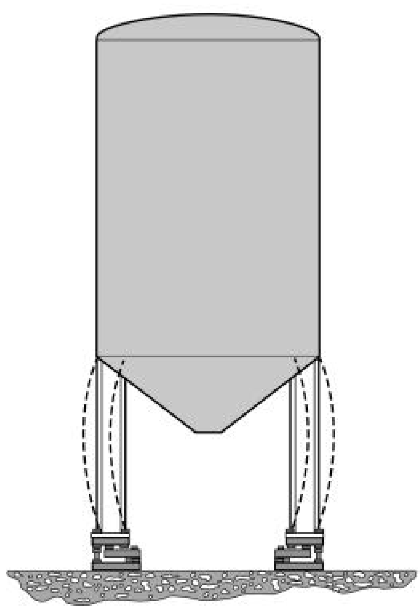


Figure 5-10a: Deflection of Tank Legs

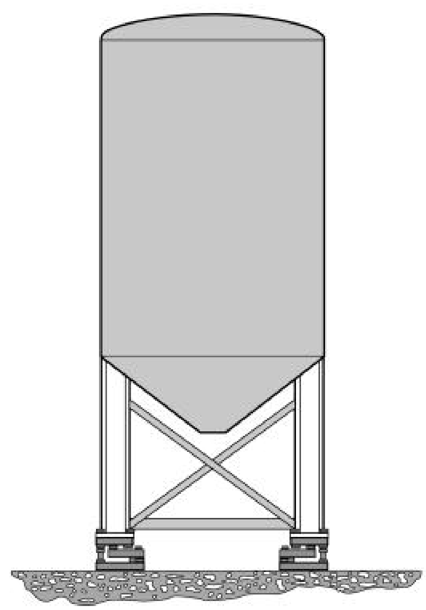


Figure 5-10b: Tank Legs Braced

Weigh Module and Support Beam Alignment

The center line of load application on a load cell should align with the center line of the weigh module's support beam. Ideal installations for a compression weigh module and tension weigh module are shown in Figure 5-11a and Figure 5-11b.

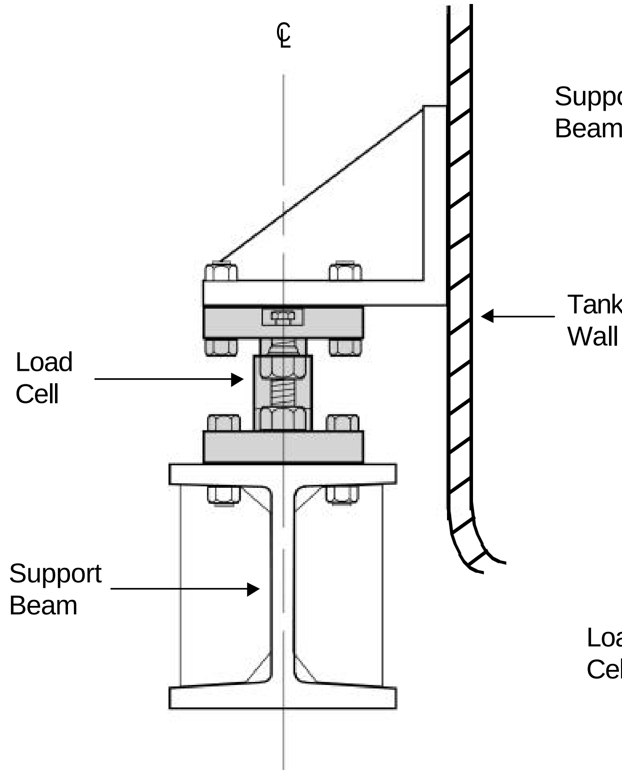


Figure 5-11a: Compression Weigh Module

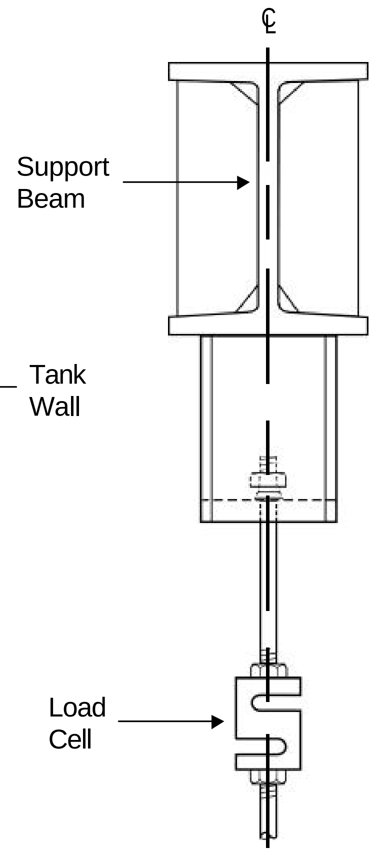


Figure 5-11b: Tension Weigh Module

Add web stiffeners or gussets if necessary to prevent the beam from twisting under load (see Figure 5-12).

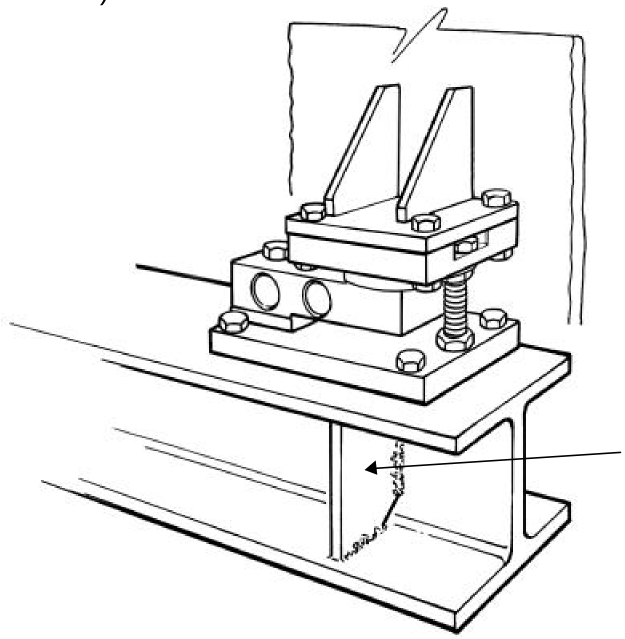


Figure 5-12: Reinforced Weigh Module Support Beam

Stiffening Support Structures

Metal support structures tend to bend or deflect as the amount of weight placed on them increases. Too much deflection can affect the accuracy of a tank scale. The greatest potential for deflection occurs when a weigh module is mounted at the middle of a support beam's span. Figure 5-13a shows how a support beam can deflect when a weigh module is mounted at mid-span. If this type of arrangement cannot be avoided, you should reinforce the support beams to minimize deflection. Figure 5-13b and Figure 5-13c show typical reinforcement methods.

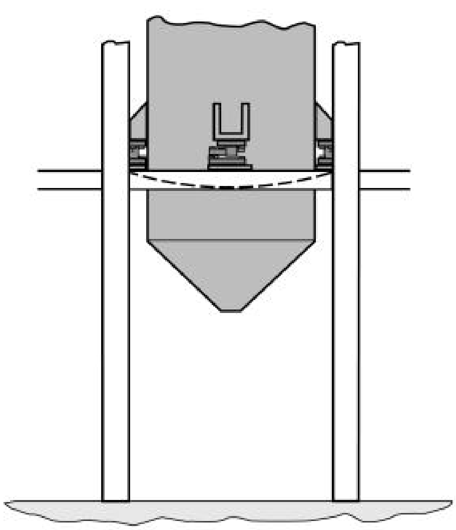


Figure 5-13a

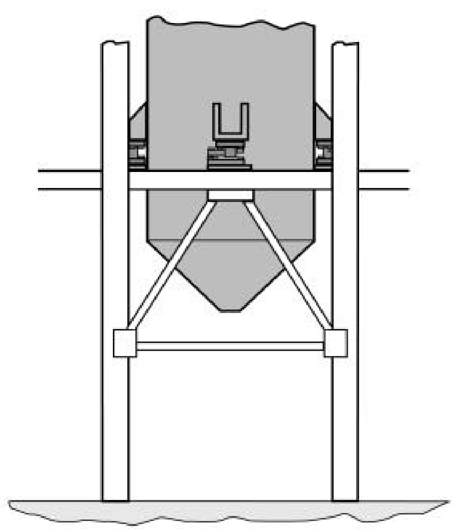


Figure 5-13b

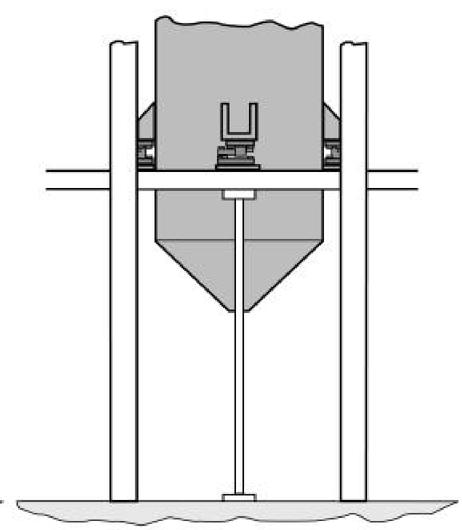


Figure 5-13c

Structural Beam Support

A better way to reduce deflection is to mount weigh modules near grounded vertical columns instead of at the center of horizontal support beams. Be sure to support all weigh modules with the same size structural beams to prevent differential deflection, which can cause nonrepeatability or zero-return problems. Figure 5-14a shows a recommended arrangement with weigh modules mounted near vertical beams, and Figure 5-14b shows weigh modules mounted at the center of horizontal beams.

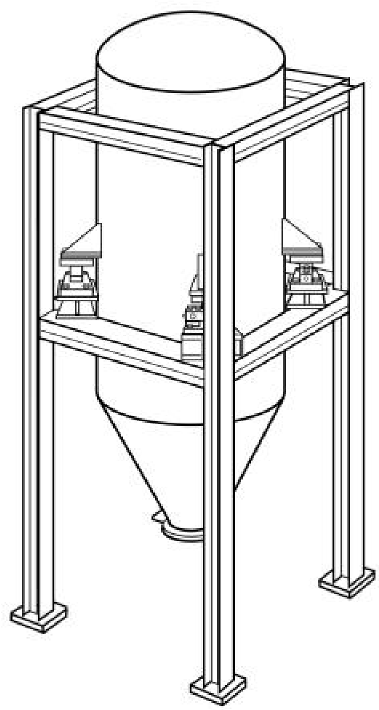


Figure 5-14a: Recommended

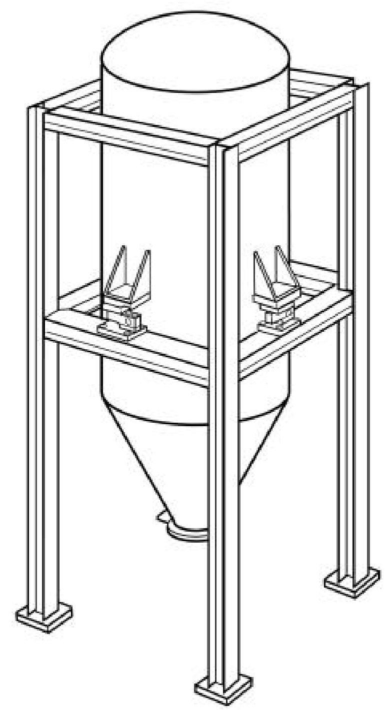


Figure 5-14b: Not Recommended

Figures 5-15 and Figure 5-16 show details of methods used to mount weigh modules near grounded vertical beams.

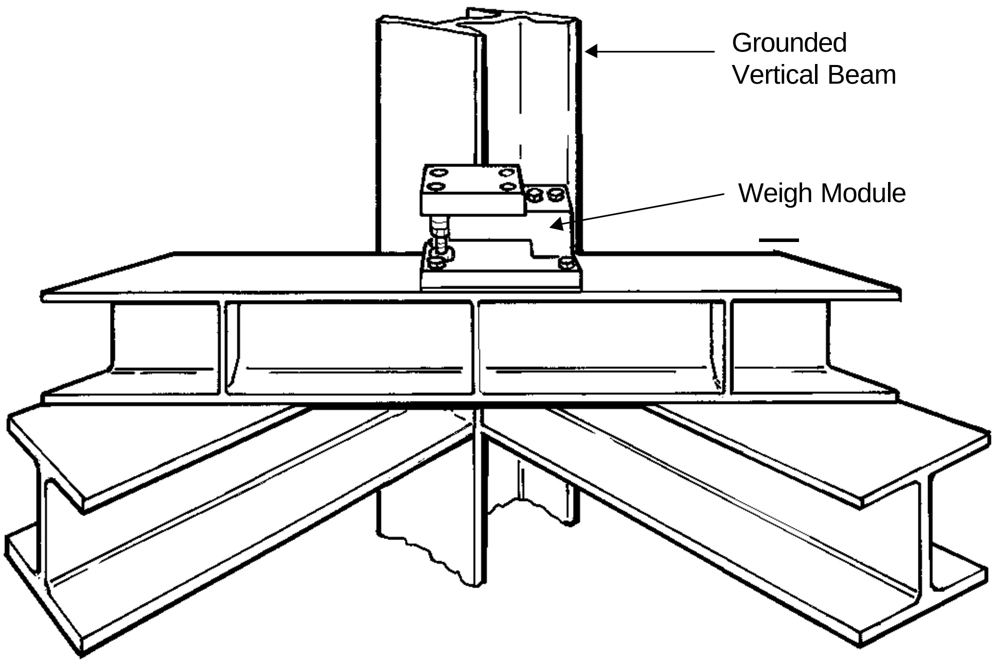


Figure 5-15: Structural Beam Support

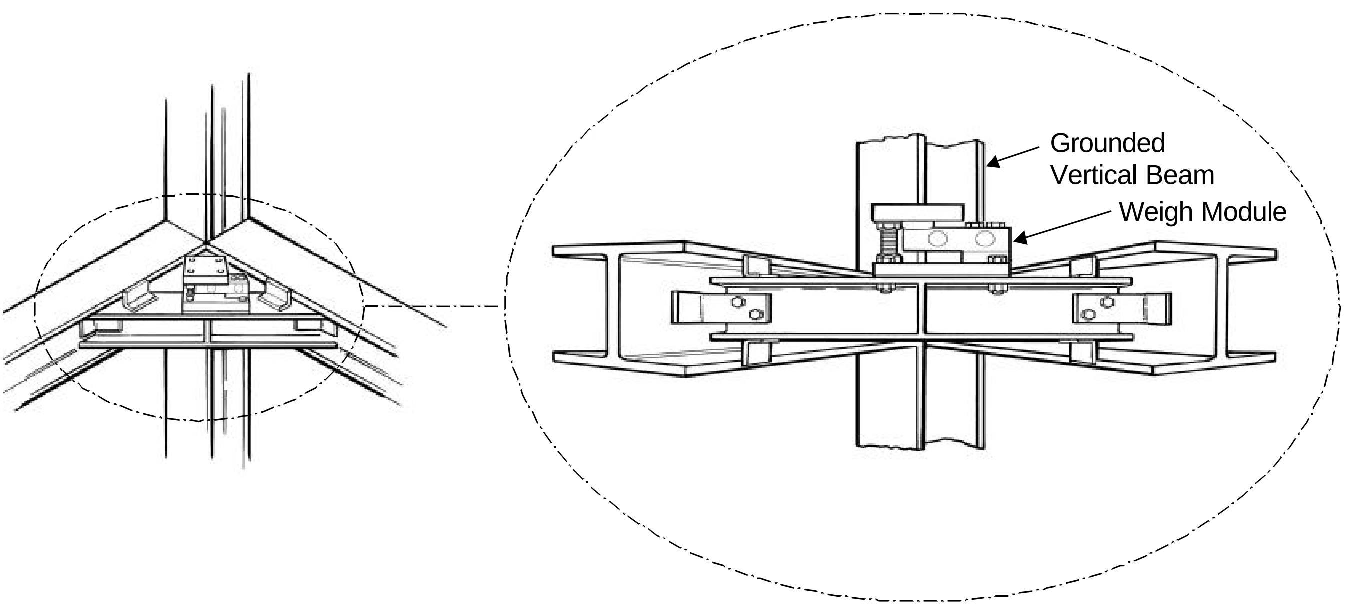


Figure 5-16: Structural Beam Support

Tank Interaction

When tank scales are located next to each other, the weight of one tank can affect the load sensed by the other tank's weigh modules. There is a strong potential for this type of interaction when the tanks share a common foundation. The following figures show four tank scale installations, ranging from best (Figure 5-17a) to worst (Figure 5-17d).

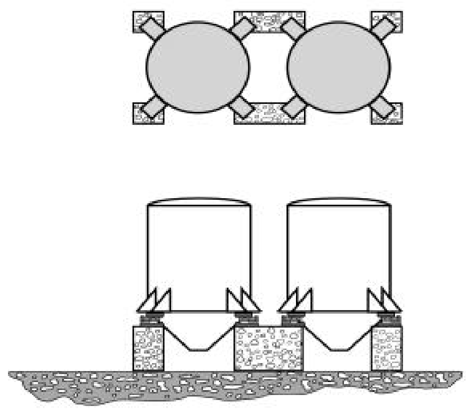


Figure 5-17a

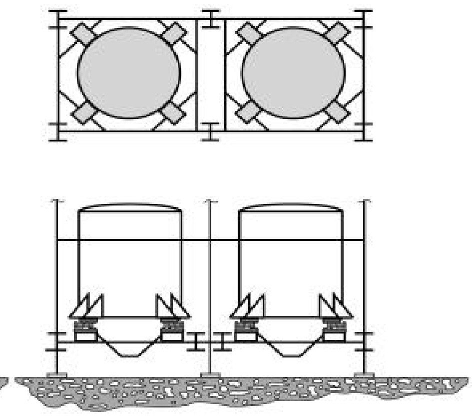


Figure 5-17b

Figure 5-17a: The best choice is to mount weigh modules on concrete foundations. Since concrete deflects very little, two tanks can share the same foundation without interacting.

Figure 5-17b: The next best choice is to mount the weigh modules near vertical beams, with a separate support structure for each tank. This limits deflection and tank interaction.

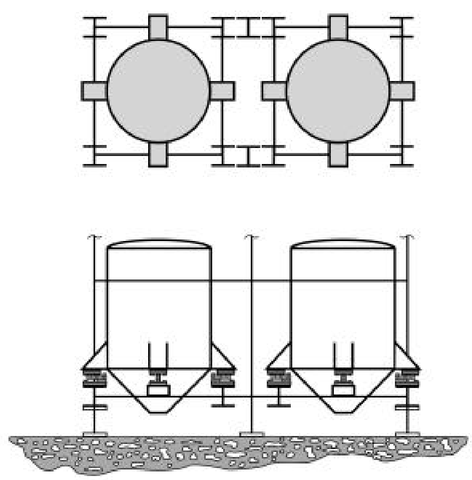


Figure 5-17c

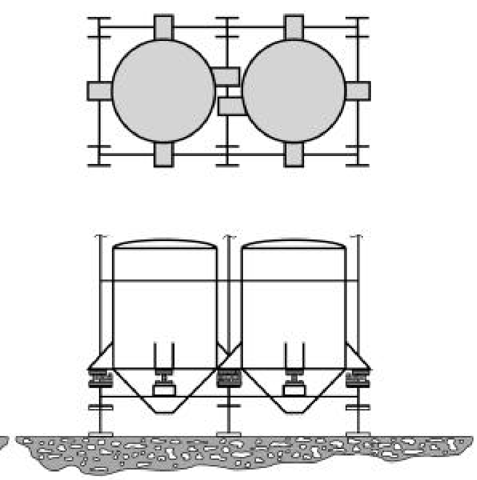


Figure 5-17d

Figure 5-17c: The next to the worst choice is to mount the weigh modules at the mid-span of a horizontal beam, using a separate support structure for each tank. This limits vessel interaction but not support structure deflection.

Figure 5-17d: The worst choice is to mount the weigh modules at the mid-span of a horizontal beam, with the two tanks sharing a common support structure. This allows both deflection and vessel interaction.

Additional Vessel Restraint Methods

Most METTLER TOLEDO compression weigh modules are designed to be self-checking and provide adequate protection against tipping. But in applications with a potential for excessive wind or seismic load forces, additional restraint systems are often needed. For suspended tension weigh module applications, a safety restraint system is always needed to catch the tank in case its suspension components fail.

Check Rods

Check rods are used to limit a tank's horizontal movement so that it will not tip or rotate. They should be positioned at or above the center of gravity of the full tank. Figure 5-18 shows recommended check rod arrangements. Note that the rods are tangential to the tank, with a gap between the nuts on the end of the rods and the brackets on the tank. This enables the rods to restrain the tank while allowing for minor thermal expansion and contraction. When check rods are installed in a perfectly horizontal position, they do not create vertical forces that will affect the scale's weight readings.

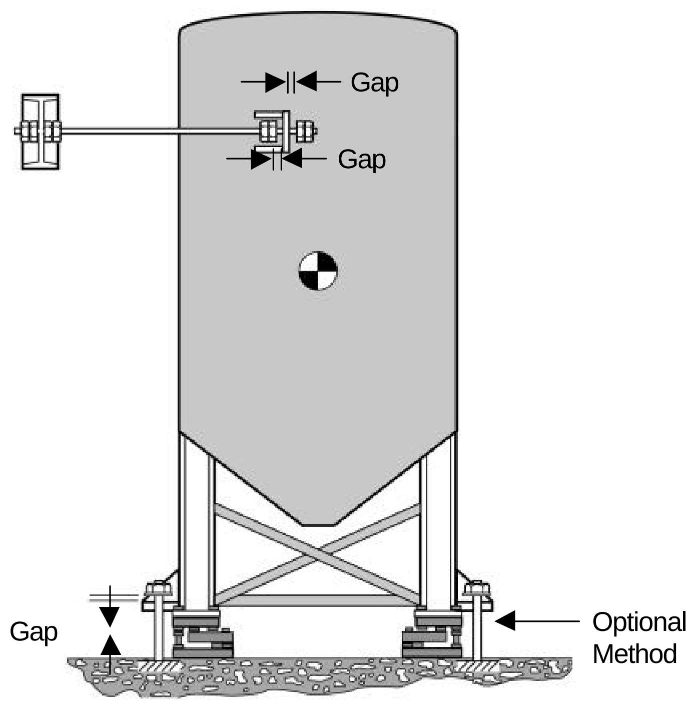


Figure 5-18: Tank with Check Rods

Safety Rods

Any tank that is suspended by tension weigh modules should have a secondary safety restraint system. Safety rods must be strong enough to support the filled tank in case the primary suspension system fails. For most applications, you would install one vertical safety rod next to each tension weigh module (see Figure 5-19). Fit each safety rod through an oversized hole in the bracket so that the rod does not influence the live weight readings. Horizontal check rods or bumpers can be used around the perimeter of the tank to keep it from swaying.

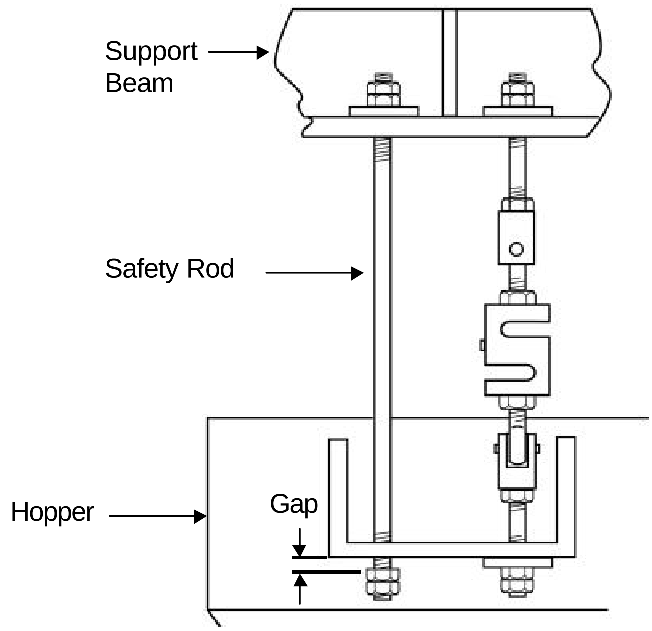


Figure 5-19: Tension Weigh Module with Safety Rod

Piping Design

Any time that piping is connected to a tank scale (a live-to-dead connection), there is a potential for mechanical binding. If piping is not installed properly, it can cause weighing errors by pushing or pulling on the tank. The best way to avoid those problems is to design piping so that it does not exert unwanted forces on a tank. Here are some general guidelines you should follow when designing a piping system:

- Make sure the tank's support structure deflects as little as possible. That will decrease the amount of deflection in the piping.
- Run all pipes horizontally from the tank so that the tank is not suspended by the piping.
- Locate the first rigid support for the piping as far away from the tank as possible. That will make the piping more flexible.
- Use pipe with the smallest diameter and lightest gauge possible. That will make the piping more flexible.
- Use flexible piping or connections whenever possible.

Why is it important for piping to be flexible? Figure 5-20a shows a tank mounted on weigh modules and supported by an I-beam. A pipe is connected to the tank and rigidly clamped to another structure at a distance (*L*) from the tank. When the tank is empty, the pipe remains in a horizontal position and exerts no force on the tank. When the tank is full (see Figure 5-20b), it moves downward because of the deflection of the load cell and the I-beam. This pulls the pipe downward the same distance that the tank deflects (Δh). The pipe exerts an upward force on the tank, affecting weight measurements. The more flexible the piping is, the less force it will exert on the tank.

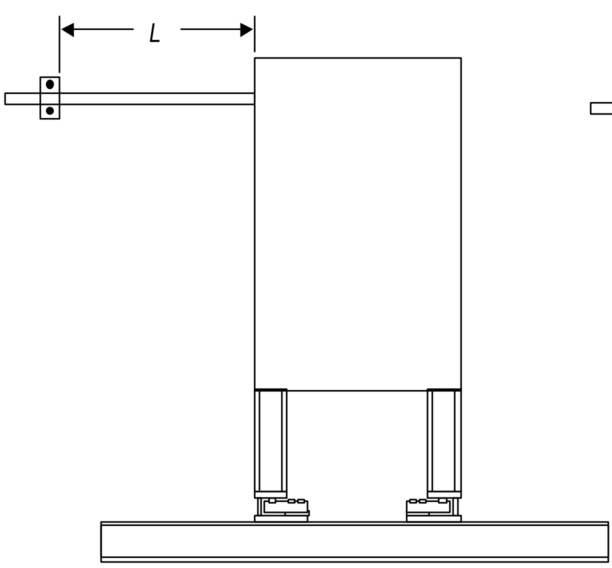


Figure 5-20a: Empty Tank

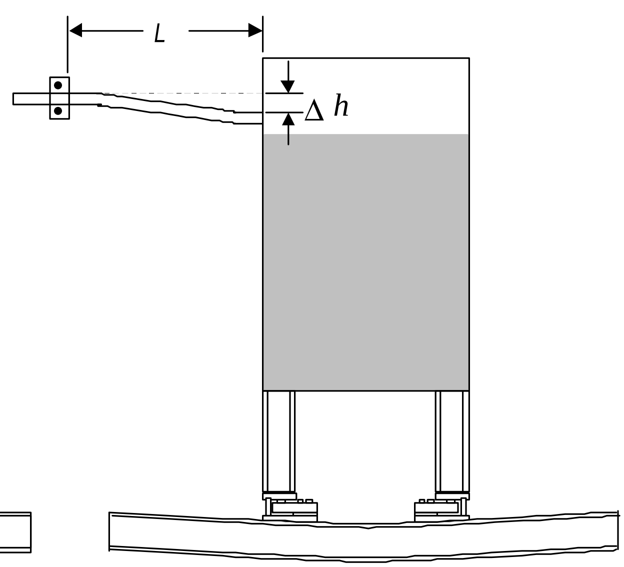


Figure 5-20b: Full Tank

Piping can have a significant effect on weighing accuracy, especially when many pipes are connected to a tank with a relatively low capacity. By designing the piping properly, you can reduce unwanted forces to a fraction of the tank's live load. Then you can compensate for the remaining forces when you calibrate the scale. Since load cell simulators cannot simulate the forces produced by attached piping, calibration must be performed on the installed tank scale.

You can use the following equation to calculate the force exerted by an attached pipe:

$$F_P = \frac{0.59 \times (D^4 - d^4) \times \Delta h \times E}{L^3}$$

where:

F_P = Force exerted by pipe

D = Outside diameter of pipe

d = Inside diameter of pipe

Δh = Total deflection of pipe at the vessel relative to the fixed point. Total deflection equals the load cell deflection plus support deflection (see Appendix 7 for load cell deflection data).

E = Young's modulus

L = Length of pipe from the vessel to the first support point

The value of *E* (Young's modulus) varies for different types of material. Three common values are listed below:

- Carbon Steel = 29,000,000 pounds/inch^2 (29×10^6)
- Stainless Steel = 28,000,000 pounds/inch^2 (28×10^6)
- Aluminum = 10,000,000 pounds/inch^2 (10×10^6)

The equation assumes a rigid connection at both ends of the piping, which is generally conservative. Use it to calculate the force exerted by each attached pipe. Then add those forces to determine the total resultant force (*F*) exerted by all the piping.

Once you have calculated the resultant force, compare it to the following relationship:

$$F \le 0.1 \times \text{System Accuracy (in \%)} \times \text{Live Load (pounds)}$$

where:

For 0.1% System Accuracy, $F \le$ 1% of Live Load

For 0.25% System Accuracy, $F \le$ 2.5% of Live Load

For 0.50% System Accuracy, $F \le$ 5% of Live Load

For 1.0% System Accuracy, $F \le$ 10% of Live Load

If the resultant force satisfies this relationship, then the force exerted by the piping is small enough that you can compensate for it during calibration.

Example Calculation

Suppose a customer requires a tank scale with a system accuracy of 0.1% of the applied load. One pipe will be connected to the tank. To meet the system accuracy requirement, the vertical force exerted by the pipe (F_P) must be equal to or less than 1% times the live load of the system. For this application, assume that the live (net) load equals 25,000 pounds.

Use the resultant force formula to determine the maximum pipe force that you can compensate for during calibration:

$$F_p \le 0.1 \times 0.1 \times 25{,}000 \text{ pounds}$$

F_P cannot be greater than 250 pounds maximum pipe force.

Use the pipe force equation to calculate the actual force exerted by a pipe with the following characteristics:

D = 4 inches (Outside diameter of pipe)

d = 3.75 inches (Inside diameter of pipe)

Δh = 0.09 inch (Total deflection of pipe at the vessel)

$E = 29 \times 10^6$ (Young's modulus)

L = 60 inches (Length of pipe from the vessel to the first support point)

$$F_P = \frac{0.59 \times (256 - 197.75) \times 0.09 \times 29{,}000{,}000}{216{,}000} = 415.27 \text{ pounds}$$

Since a pipe force of 415.27 pounds is greater than 250 pounds, it would not satisfy the requirement for a 0.1% accuracy system. One solution is to increase the length of the pipe from 60 inches to 80 inches. When you recalculate the pipe force for a length of 80 inches, you get F_P = 175.2 pounds, which is well below the maximum of 250 pounds.

Piping Installation

This section shows ways to install piping in order to avoid deflection problems.

The greater the distance between the tank and the first pipe support, the more flexible the piping connection will be (see Figure 5-21a). Use a section of flexible hose so that the pipe does not exert unwanted forces when the tank deflects (Figure 5-21b).

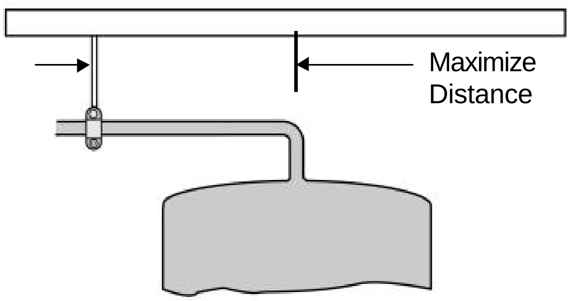


Figure 5-21a: Distance Between Tank and Pipe Support

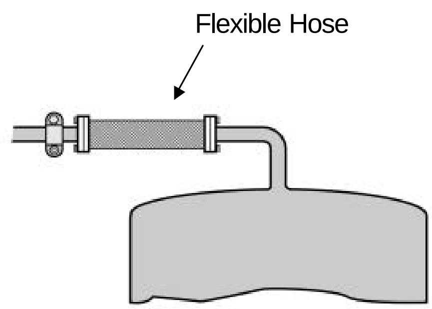


Figure 5-21b: Piping with Length of Flexible Hose

A 90-degree bend in a horizontal run of pipe will make the piping more flexible (see Figure 5-22).

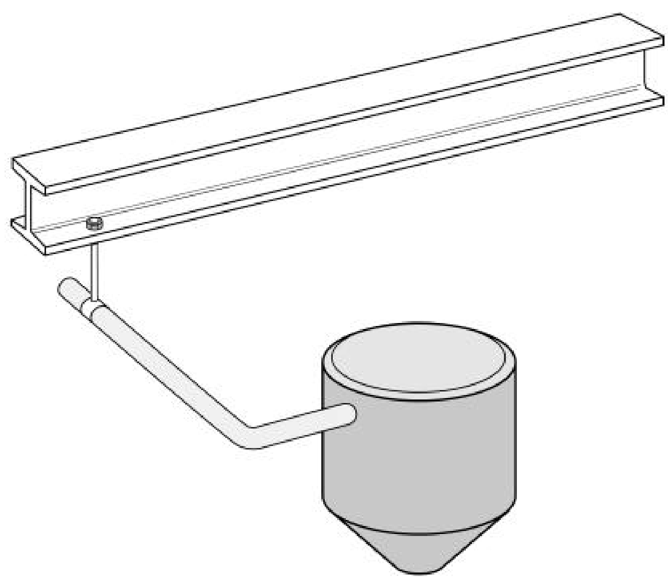


Figure 5-22: Horizontal Piping with 90-Degree Bend

When a single discharge pipe is used by adjacent tanks (see Figure 5-23a), the weight of material being discharged from one tank can exert a downward force on the other tank. Instead, design the system so that the discharge piping from each tank is supported independently and does not interact with the other tank (see Figure 5-23b).

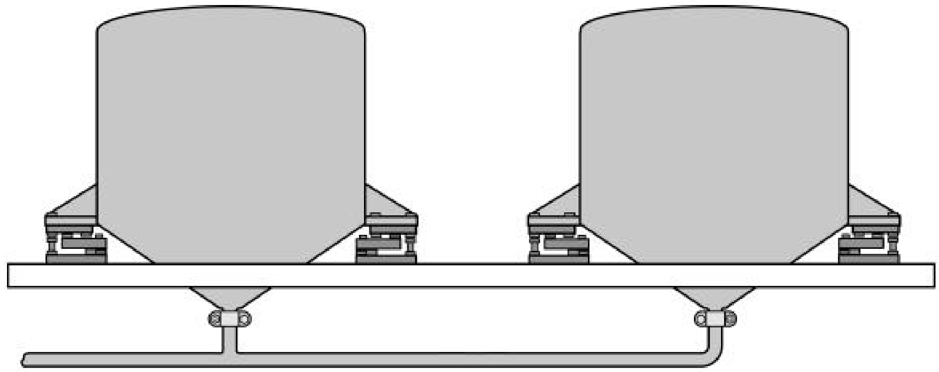


Figure 5-23a: Tanks with Single Discharge Pipe

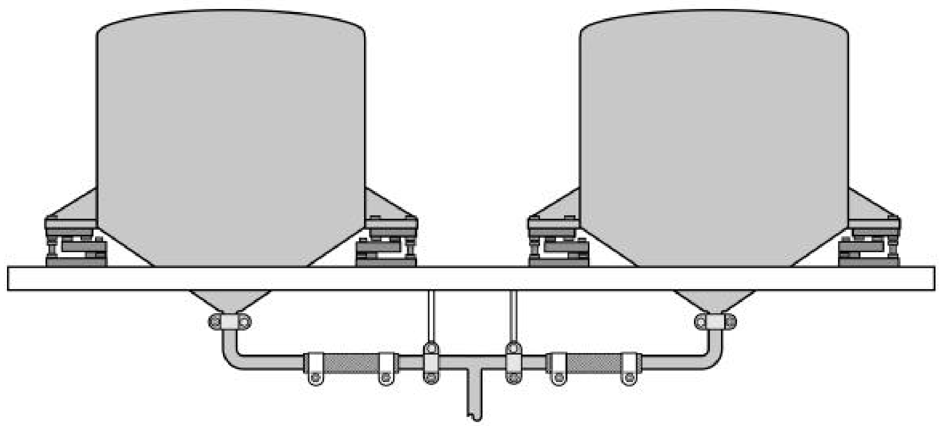


Figure 5-23b: Recommended Design for Single Discharge Pipe

Do not attach piping to supports for a mezzanine, upper floor, or other structure that deflects separately from the tank (see Figure 5-24a). Instead, attach piping to the tank's support structure so that the piping moves along with the tank (see Figure 5-24b).

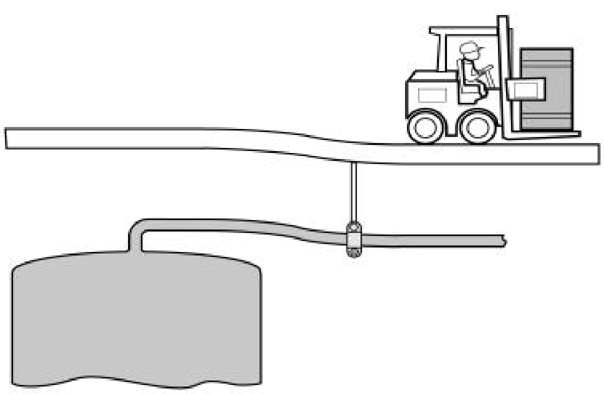


Figure 5-24a: Piping Supported by Upper Floor

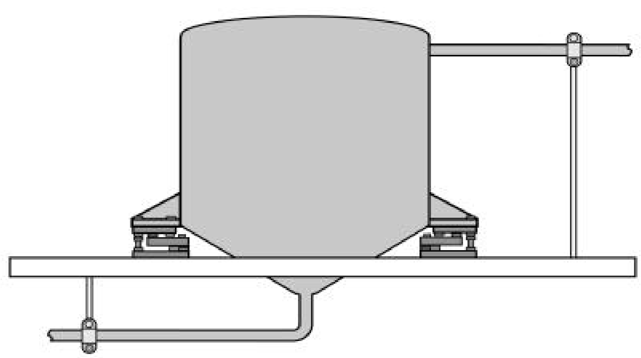


Figure 5-24b: Piping Attached to Tank's Support Structure

When possible, avoid rigid connections between piping and tanks. Note the clearance between the tank and inlet/outlet piping in Figure 5-25. A flexible boot is used to seal each connection.

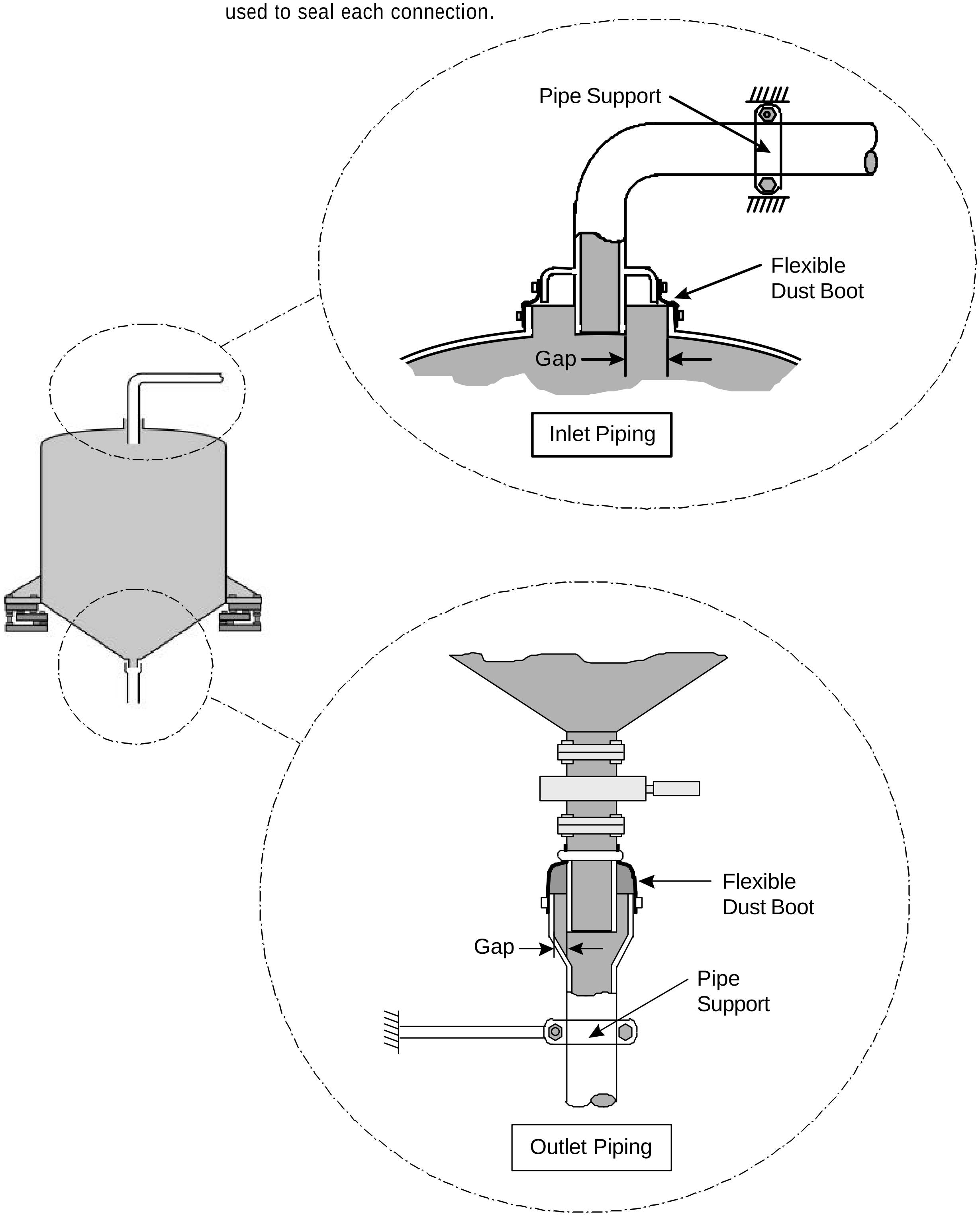


Figure 5-25: Recommended Flexible Connections Between Tank and Piping

Electrical Wiring

A weigh module system requires two types of electrical cables:

- Load cell cables to connect each load cell to a junction box (cables are usually supplied with the load cells).
- A home run cable to connect the junction box to an indicator.

Load Cell Cables

Each load cell is connected by cable to a junction box, which adds the individual load cell signals together to provide one signal that can be transmitted to the indicator. METTLER TOLEDO uses three different operating modes: analog, DigiTOL, and IDNet. For each of these operating modes, the junction box design and wiring is different.

Analog Systems

Most weighing systems use an analog junction box, which requires an analog-compatible indicator. An analog junction box can sum up to four load cells. For weigh module systems with more than four load cells, you will need to connect several junction boxes together. Sample layouts for analog systems with four and six load cells are shown in Figure 5-26. The maximum number of load cells in a weighing system depends on the indicator's power supply and the load cell bridge resistance. For analog junction box dimensions and wiring details, see Appendix 9.

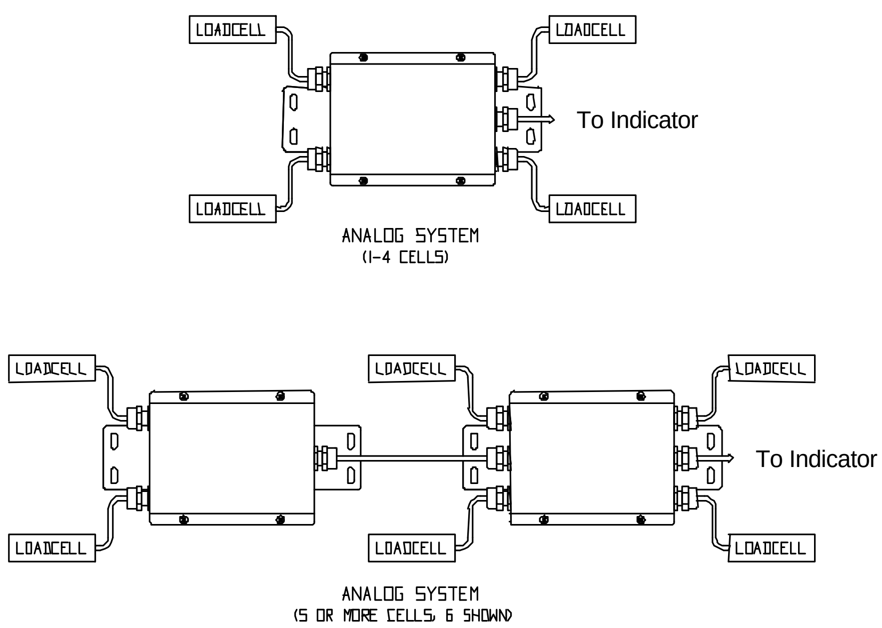


Figure 5-26: Analog Junction Box Layouts

In harsh environments, load cell cables should be protected by running them through conduit. METTLER TOLEDO supplies a large analog junction box that is equipped with 1/2-inch conduit fittings (see Figure 5-27). The box is large enough so that excess cable can be coiled and stored inside the box.

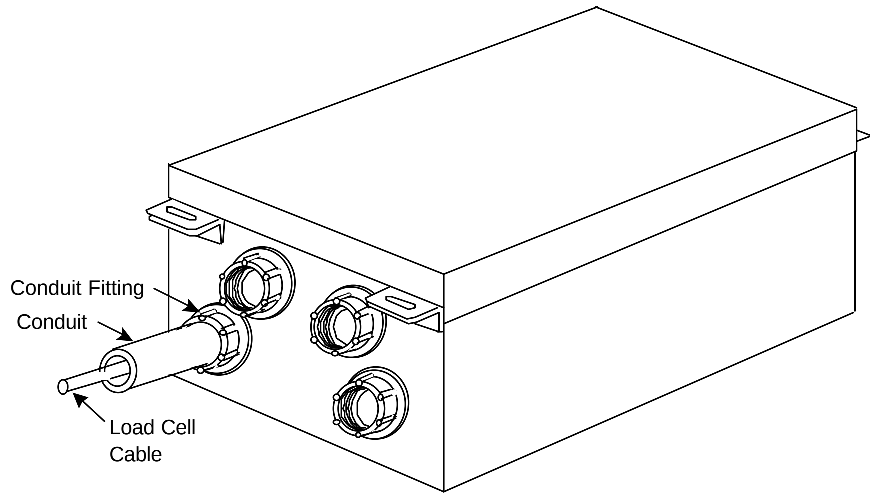


Figure 5-27: Large Analog Junction Box with Conduit Fittings

DigiTOL Systems

A DigiTOL junction box requires a DigiTOL-compatible indicator and can be connected to a maximum of four load cells. A sample layout for a DigiTOL system is shown in Figure 5-28. For DigiTOL junction box dimensions and wiring details, see Appendix 9.

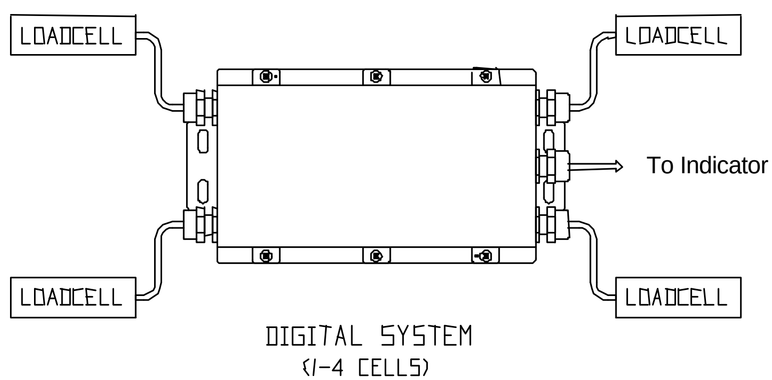


Figure 5-28: DigiTOL Junction Box Layout

IDNet Systems

An IDNet junction box can output an IDNet data format that is compatible with METTLER TOLEDO ID1 and ID5 weight displays or with a Jaguar indicator. A sample layout for an IDNet system is shown in Figure 5-29. For IDNet junction box dimensions and wiring details, see Appendix 9.

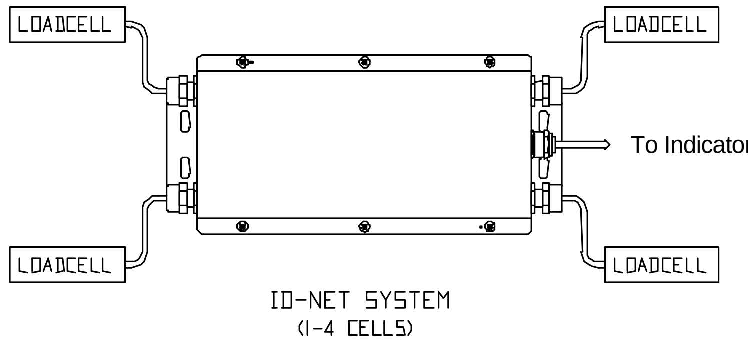


Figure 5-29: IDNet Junction Box Layout

Load Cell Cable Lengths

Normally, each load cell is supplied with a standard length of cable. Do not lengthen or shorten load cell cables in the field. **Changing the length of a load cell cable will affect the output signal from the load cell.** If a cable is too long, simply coil the excess cable and place it in or near the junction box. You can order junction boxes in sizes that are large enough to hold coiled cables. Never attach excess cable to a live portion of the weighing system. Nonstandard lengths of cable can be ordered for applications that require them.

Home Run Cables

A home run cable transmits the summed load cell signal from the junction box to the indicator. To provide accurate weight readings, a scale must be able to distinguish between electrical signals that differ by millionths of a volt. So small amounts of noise introduced through the cables can cause weighing errors. Common sources of noise are radio frequency (RF) and electromagnetic (EM) radiation produced by power cords, power lines, motors, or cellular phones.

To reduce radio frequency and electromagnetic interference, install a ferrite ring over the home run cable at the indicator. It should be placed inside a harsh enclosure or as close as possible to the connector on a panel-mount enclosure. Wrap the home run cable conductors and the shield ground wire around the ferrite ring four times (see Figure 5-30). Keep the ferrite ring as close as possible to the point where the cable enters the enclosure.

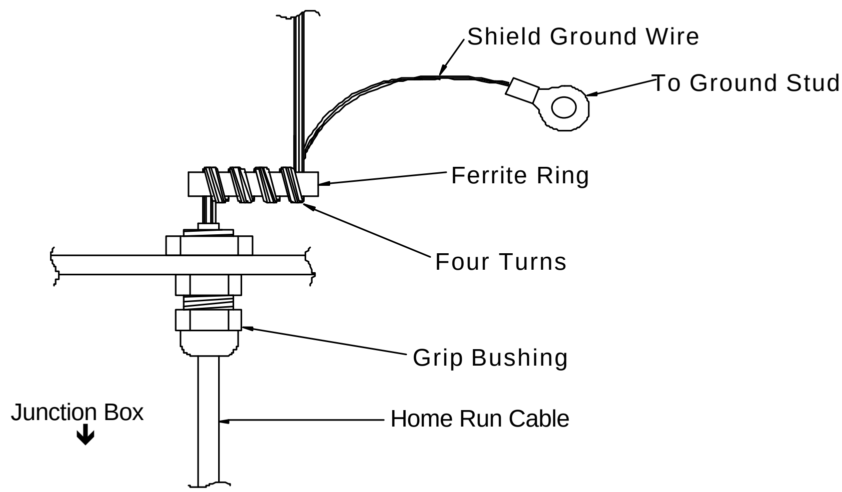


Figure 5-30: Ferrite Ring Apparatus

The following installation guidelines will also help prevent electrical interference:

- Install cables at least 12 inches from power lines.
- Fully insulate and ground cables to prevent them from picking up unwanted noise.

Cables are often exposed to mechanical damage or damage caused by water or chemicals. To protect cables from damage, encase them in flexible conduit. Teflon coatings are available to protect cables in corrosive environments. If a mixing agitator is attached to a tank, keep enough slack in the power supply cables to prevent live-to-dead load interference.

Home Run Cable Lengths

The maximum length of a home run cable varies with its conductor size (24 gauge, 20 gauge, or 16 gauge) and the type of indicator being used. You can increase the maximum length by using cables with larger conductors (Note: 16 gauge is larger than 24 gauge). If a cable exceeds the recommended length, it will cause a voltage drop that could affect weight readings.

Table 5-1 lists recommended maximum cable lengths for METTLER TOLEDO Jaguar®, Lynx®, LynxBatch®, and Panther® indicators. The maximum cable length is based on total scale resistance (TSR), which is the load cell input resistance (ohms) divided by the number of load cells. Panther, Lynx, and LynxBatch indicators can be used with as many as eight load cells. A Jaguar indicator can be used with as many as ten load cells.

The recommended maximum cable length for a Puma® indicator with one to four load cells is 400 feet for 22-gauge cable or larger.

Number of Load Cells	TSR (ohms)	24 Gauge (feet)	20 Gauge (feet)	16 Gauge (feet)
1	350	800	2,000	4,000
3-4	117-87	200	600	1,000
6-8	58-44	100	300	500
10*	35	70	190	350

*Jaguar indicator only.

Table 5-1: Recommended Maximum Home Run Cable Lengths

We recommend using a dual-shield cable design to protect the signal from electromagnetic and radio frequency interference. A cross section of this type of home run cable is shown in Figure 5-31.

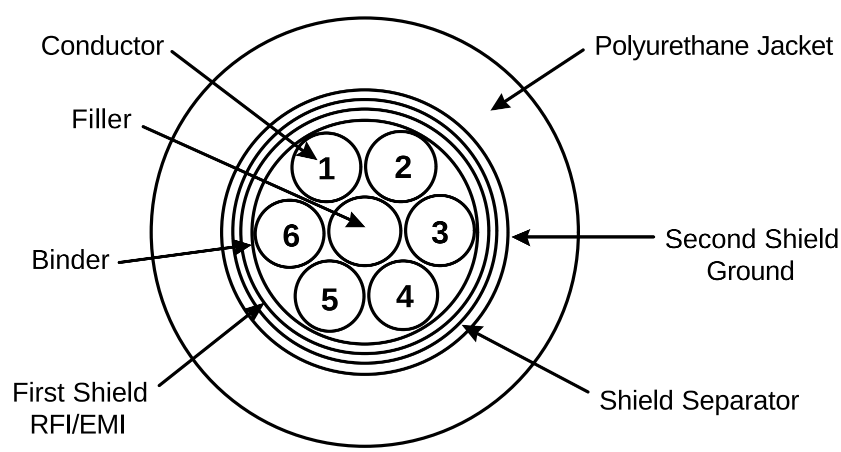


Figure 5-31: Cross Section of Dual-Shield Home Run Cable

6 Flexmount Weigh Modules

Flexmount weigh modules are designed for static loading applications such as tanks, hoppers, and vessels. Typically, the only force that needs to be considered is the weight of the tank and its contents (the vertical force pressing down on the top plate of the weigh module). Each weigh module has five basic components, which are shown in Figure 6-1.

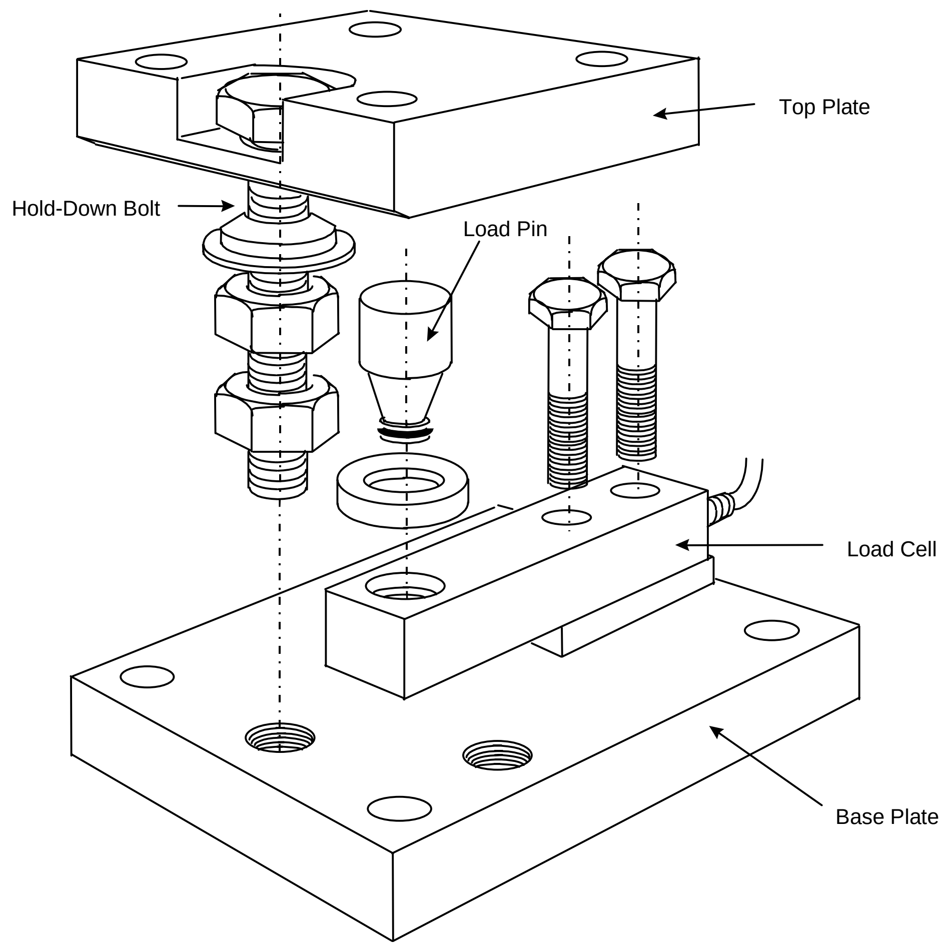


Figure 6-1: Flexmount Weigh Module

Base Plate: This bottom plate is bolted or welded to the floor, foundation, or other support structure to hold the weigh module in place.

Load Cell: This transducer uses a strain gauge to convert the mechanical force exerted by the weight of a tank into an electric signal that provides a weight reading on an indicator. The cantilever-beam load cell is bolted to the weigh module's base plate.

Top Plate: This plate is bolted or welded to a tank or other structure so that it receives the weight of the tank.

Hold-Down/Jacking Bolt: This bolt connects the top plate to the base plate in order to check any uplift forces that might cause the tank scale to tip. Clearance must be maintained between the bolt and the top plate so that the bolt does not receive any of the weight that is being transferred to the load pin. This bolt can also be used to jack up an empty tank so that the load cells can be replaced if necessary.

Sizing Weigh Modules

To design a tank scale that will weigh its contents accurately, you must use weigh modules with the proper load cell capacity. There are three main factors in sizing weigh modules for a tank scale: (1) the weight of the empty tank, (2) the weight of the tank's contents when full, and (3) the number of weigh modules. The number of weigh modules will equal the number of legs or supports that the tank has.

A standard safety factor of 1.25 is normally figured into the calculation to compensate for uneven load distribution and any underestimation of weights. Certain installations might have special environmental considerations requiring additional safety factors. Environmental considerations are discussed in Chapter 4.

Calculating Weigh Module Size

Suppose that you want to add weigh modules to a tank designed to hold 20,000 pounds of a liquid. The tank itself weighs 10,000 pounds and stands on four legs. Assume that only the standard safety factor is needed for this installation. To determine what size weigh modules you will need, calculate the total weight of the tank and its contents, figure in any safety factors, and then divide by the number of weigh modules.

20,000 lb	Weight of liquid
+10,000 lb	Weight of empty tank
30,000 lb	Total weight
x 1.25	Safety factor
37,500 lb	Adjusted weight
÷ 4	Number of weigh modules
9,375 lb	Weight per weigh module

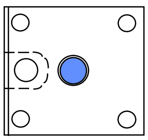
Since each weigh module will need to handle up to 9,375 pounds, the best choice for the job would be weigh modules with a capacity of 10,000 pounds each.

Selecting Material

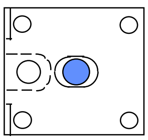
Load cells and other weigh module components can be manufactured of carbon steel or stainless steel. Weigh modules that will be exposed to wet or corrosive environments are generally made of stainless steel. When selecting weigh modules, you will need to consider the environment in which they will be used and the materials that your facility will handle. Appendix 12 provides a chemical resistance chart to aid in selecting materials.

Weigh Module Orientation

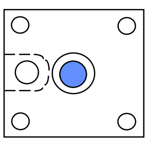
In a typical tank scale application, three or four weigh modules would be used to support the tank. To provide accurate weighing, this system of weigh modules must allow for the thermal expansion and contraction of the tank. A Flexmount weigh module system does this by incorporating three different top plate designs:



FIXED



SEMI-FLOATING



FULL FLOATING

Fixed Pin: The opening in the underside of the top plate is sized to hold the load pin securely. This anchors the weigh module system by providing a fixed point that allows no horizontal movement.

Semi-Floating Pin: The opening in the underside of the top plate is sized to allow the load pin to move in two directions. This accommodates expansion and contraction but keeps the scale from rotating around the fixed pin.

Full-Floating Pin: The opening in the underside of the top plate is sized to allow the load pin to move in any horizontal direction.

An installation should include one fixed-pin weigh module and one semi-floating pin weigh module. The semi-floating pin module should be positioned directly across from the fixed-pin module or at the support location farthest from the fixed-pin module. Full-floating weigh modules should be used at all other support locations. Tank legs or structural support lugs must be rigid enough so that the weight of the full tank does not cause them to spread out.

The top plates on Flexmount weigh modules can be turned 90 degrees for tangential or radial mounting. Recommended mounting arrangements are shown in Figure 6-2.

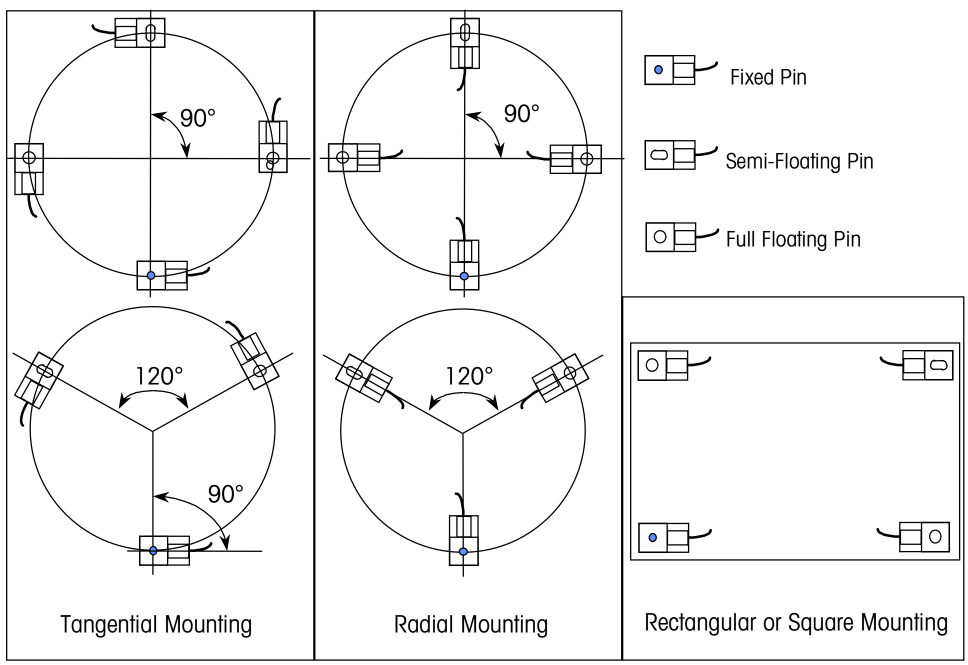


Figure 6-2: Plan View of Mounting Arrangements

Installation

The actual installation procedure will depend on the specific requirements of an application. One of the first things to consider is the foundation on which the tank scale will be placed. This is usually a concrete floor or steel support structure. Whichever you are using, you will need to make sure that it is strong enough to remain rigid under the weight of the full tank scale. The base plate bearing data in Table 6-1 lists the pressure that each weigh module will exert on its foundation.

0958 Flexmount Weigh Module lb (kg)	Base Plate Bearing psi (pascal)	Top Plate Bolts (Metric)	Base Plate Bolts (Metric)
250, 500, 1.25K, 2.5K & 5K (220, 550, 1100 & 2200)	159 (1,094,413)	3/8″-16 UNC (M10 x 1.5)	3/8″-16 UNC (M10 x 1.5)
10K (4400)	180 (1,242,306)	5/8″-11 UNC (M16 x 2)	5/8″-11 UNC (M16 x 2)
20K	179 (1,231,214)	3/4″-10 UNC (M20 x 2.5)	3/4″-10 UNC (M20 x 2.5)
30K	268 (1,846,821)	3/4″-10 UNC (M20 x 2.5)	3/4″-10 UNC (M20 x 2.5)
45K	312 (2,154,625)	1″-8 UNC (M24 x 3)	1″-8 UNC (M24 x 3)
Bolts should be GR.5 / ASTM A325 minimum			

Table 6-1: Flexmount Bearing Support and Mounting Bolt Sizes

General Procedure

1. Position a weigh module under each of the tank's support legs or mounting lugs, and slowly lower the tank onto the weigh modules. The jam nut and centering washer on each weigh module's hold-down bolt should be tightened against the top plate so that no weight will be placed on the load cell.
2. Make sure that each load point on the tank is well supported by a weigh module's top plate and that all top plates are level within ±1/16 inch. Otherwise, add shims until each load point is supported and the top plates are level.
3. Bolt or weld the top plate of each weigh module to the support leg or mounting lug that is resting on it. For welding use a 3/8-inch fillet, 1 inch long on 3-inch centers.

⚠ CAUTION

DO NOT PASS WELDING CURRENT THROUGH THE LOAD CELLS! WHEN WELDING ON A SCALE, ALWAYS GROUND THE WELDING DEVICE AS CLOSE TO THE WORK AS POSSIBLE. NEVER WELD CLOSER THAN 4 FEET (1.2 METERS) TO ANY LOAD CELL WITHOUT REMOVING THE LOAD CELL.

4. Lower the tank onto the support foundation (concrete slab or support beam). Mark the position of the base plate mounting holes on the foundation (see Figure 6-3). METTLER TOLEDO can supply templates for the bolt holes.

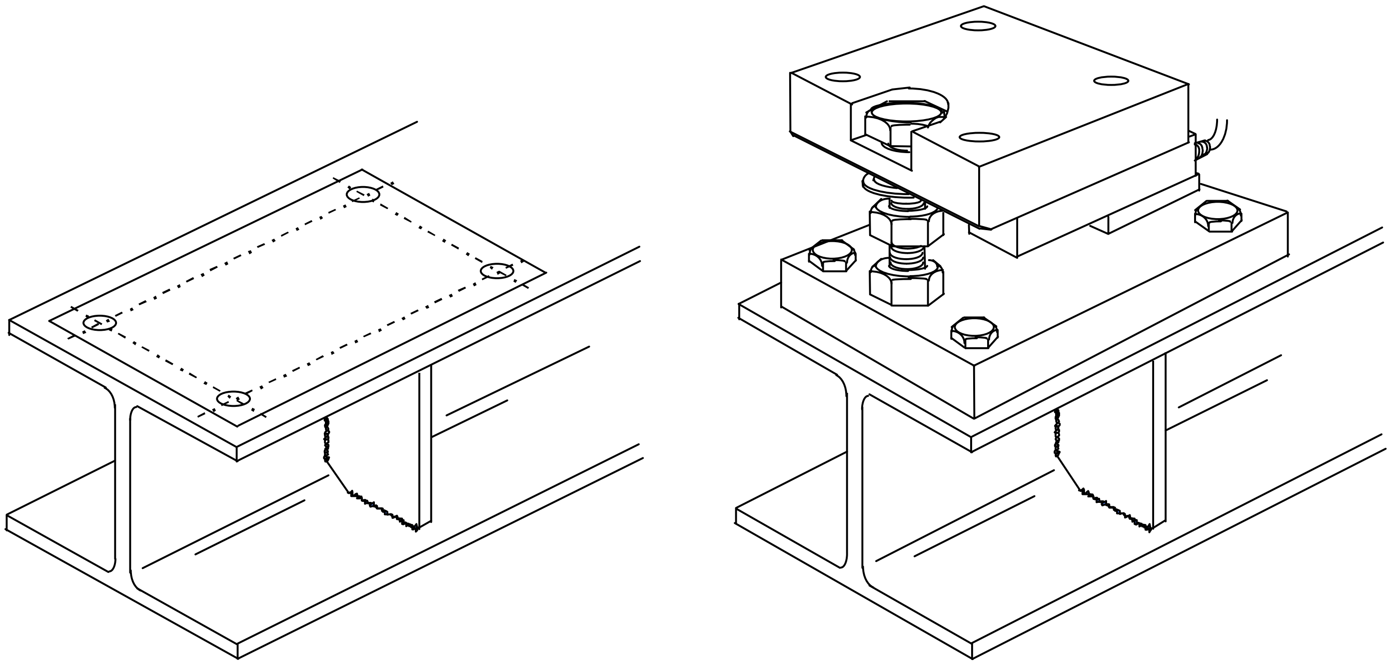
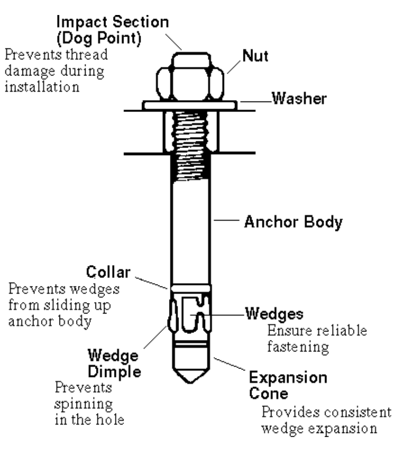


Figure 6-3: Locating Bolt Holes in Support Steel

5. Raise the tank out of the way and drill the appropriate size anchoring holes in the support foundation.
6. Anchor the weigh module base plates to the foundation, using the instructions given below for the appropriate type of foundation. Level each base plate to within ±1/16 inch. All base plates must be in the same level plane within ±1/8 inch.

For a Level Concrete Floor Foundation:
Lower the tank back onto the foundation so that the base plate mounting holes line up with the holes that were drilled in the concrete. Insert a wedge-design expansion anchor bolt into each base plate mounting hole (see Figure 6-4). Follow the anchor bolt manufacturer's instructions regarding the size and depth of holes and recommended torque values.



Expansion Anchor Bolt Detail

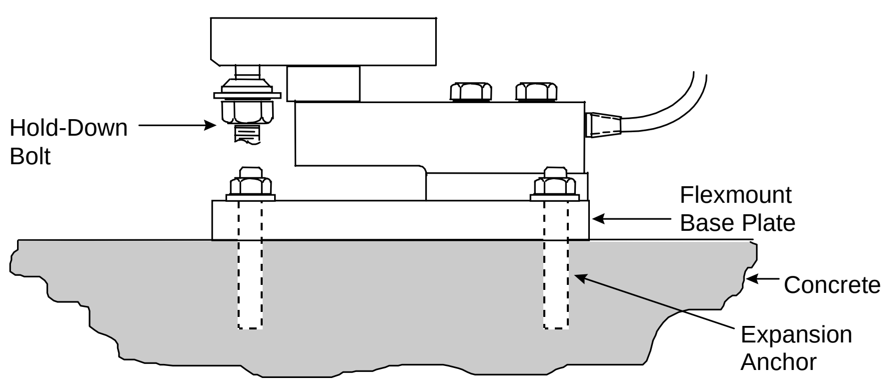


Figure 6-4: Base Plate Bolted to Level Concrete Floor

Note: If you use J-bolt anchors, you will need to place them in the concrete accurately before attaching the weigh modules to the tank supports. Make sure that the tank support holes allow room for adjustment so that the modules can be aligned properly.

For an Unlevel Concrete Floor Foundation:
Install threaded epoxy inserts or J-bolts in the foundation to support the base plates. Place leveling nuts and washers beneath the base plates to adjust for level. Keep the space between each base plate and the concrete floor to a minimum, and fill it with a nonshrink, epoxy grout once all base plates are level and in the same plane (see Figure 6-5).

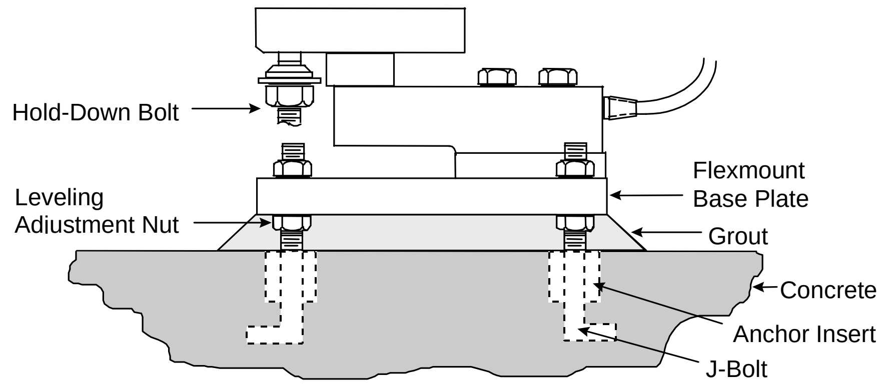


Figure 6-5: Base Plate Bolted to Unlevel Concrete Floor

For a Structural Beam Foundation:
Use through bolts, washers, and nuts to anchor the base plate to the flange of the structural beam (see Figure 6-6). Install web stiffeners to prevent the beam from twisting. If shimming is required to level the base plates or to keep them in the same plane, add the shim beneath the entire base plate. If you are welding the base plates to the beam, use a 3/8-inch fillet, 1 inch long on 3-inch centers.

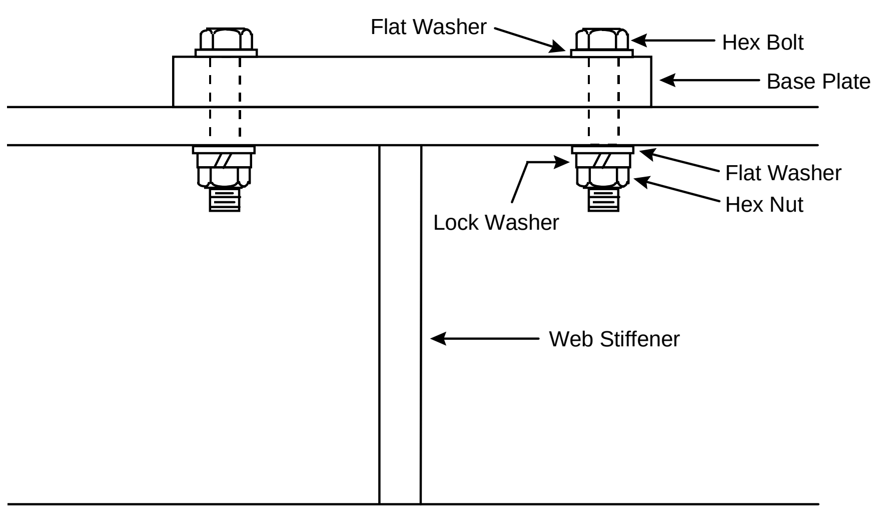


Figure 6-6: Base Plate Bolted to Structural Beam

7. After securing all the top plates and base plates, slowly back out the nut and centering washer on each hold-down bolt, carefully lowering the top plate and weigh structure onto the load cells.

8. After all the top plates are down and applying load to the load cells, make sure there is adequate clearance between the hold-down bolt and retaining hole. See the hold-down bolt assembly shown in Figure 6-7.

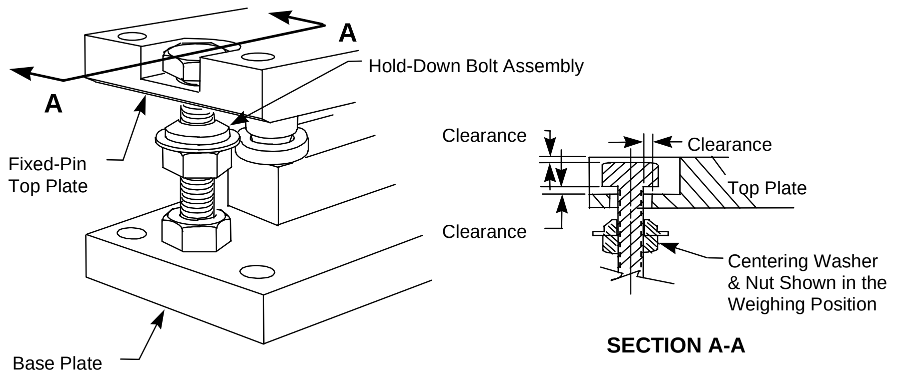


Figure 6-7: Flexmount Hold-Down Bolt Assembly

8. Mount the junction box in a location where the load cell cables can be properly terminated in the junction box. Do not mount the junction box on the scale.

   Note: Each load cell is supplied with a standard length of cable. Do not lengthen or shorten load cell cables in the field! Changing the length of a load cell cable will affect the output signal from the load cell. If a cable is too long, simply coil the excess cable and place it in or near the junction box. Nonstandard lengths of cable can be ordered for applications that require them.

9. Connect the load cell cables to the junction box and terminate the wires according to the wiring and color code decal on the underside of the junction box lid.

10. Connect the home run cable from the scale indicator to the junction box.

11. Confirm that all live-to-dead connections (such as piping) are flexible and securely anchored at both the scale and dead connection point.

7

Flexmount HD Weigh Modules

Flexmount HD weigh modules are heavy-capacity units designed for static loading applications such as tanks, hoppers, and vessels. Typically, the only force that needs to be considered is the weight of the tank and its contents (the vertical force pressing down on the top plate of the weigh module). Each weigh module has five basic components, which are shown in Figure 7-1.

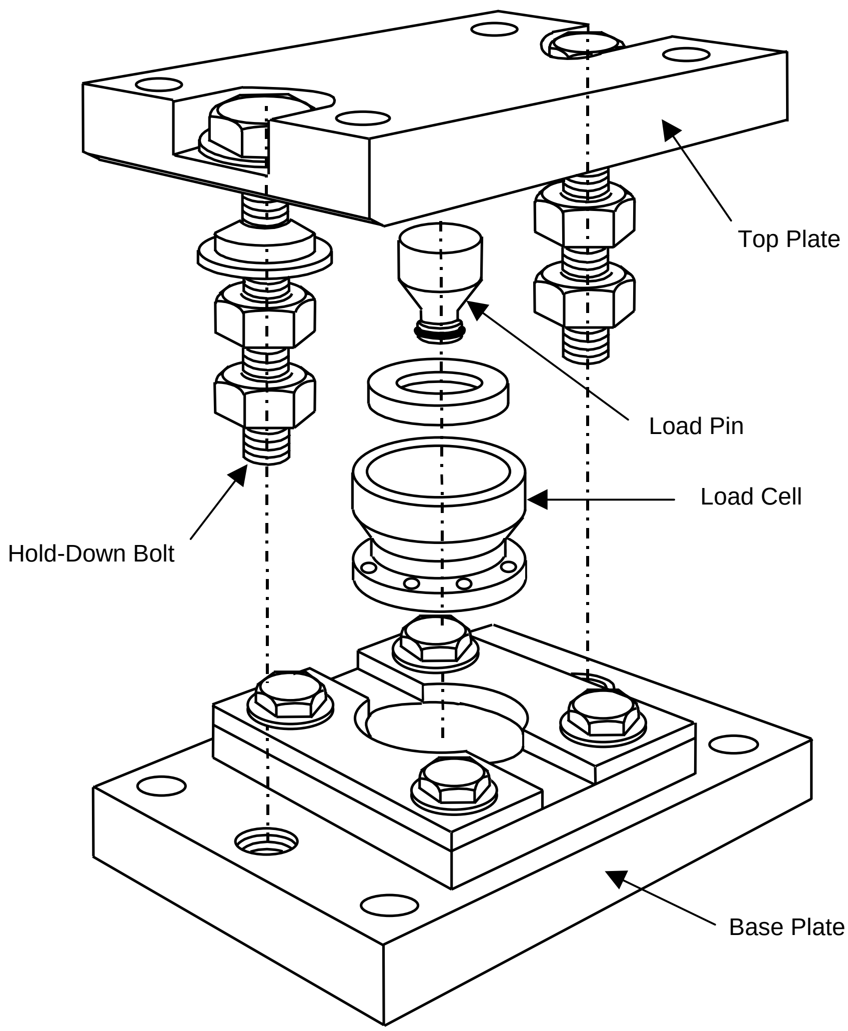


Figure 7-1: Flexmount HD Weigh Module

Base Plate: This bottom plate is bolted or welded to the floor, foundation, or other support structure to hold the weigh module in place.

Load Cell: This transducer uses a strain gauge to convert the mechanical force exerted by the weight of a tank into an electric signal that provides a weight reading on an indicator. The torsion-ring load cell is bolted to the weigh module's base plate.

Load Pin: This pin fits into an opening in the underside of the top plate. It transfers weight from the top plate to a single point on the load cell.

Top Plate: This plate is bolted or welded to a tank or other structure so that it receives the weight of the tank.

Hold-Down/Jacking Bolts: These bolts connect the top plate to the base plate in order to check any uplift forces that might cause the tank scale to tip. Clearance must be maintained between the bolts and the top plate so that the bolts do not receive any of the weight that is being transferred to the load pin.

Sizing Weigh Modules

To design a tank scale that will weigh its contents accurately, you must use weigh modules with the proper load cell capacity. There are three main factors in sizing weigh modules for a tank scale: (1) the weight of the empty tank, (2) the weight of the tank's contents when full, and (3) the number of weigh modules. The number of weigh modules will equal the number of legs or supports that the tank has.

A standard safety factor of 1.25 is normally figured into the calculation to compensate for uneven load distribution and any underestimation of weights. Certain installations might have special environmental considerations requiring additional safety factors. Environmental considerations are discussed in Chapter 4.

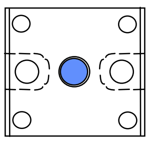
Calculating Weigh Module Size

Suppose that you want to add weigh modules to a tank designed to hold 200,000 pounds of a liquid. The tank itself weighs 100,000 pounds and stands on four legs. Assume that only the standard safety factor is needed for this installation. To determine what size weigh modules you will need, calculate the total weight of the tank and its contents, figure in any safety factors, and then divide by the number of weigh modules.

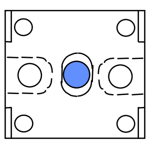
200,000 lb	Weight of liquid
+100,000 lb	Weight of empty tank
300,000 lb	Total weight
x 1.25	Safety factor
375,000 lb	Adjusted weight
÷ 4	Number of weigh modules
93,750 lb	Weight per weigh module

Since each weigh module will need to handle up to 93,750 pounds, the best choice for the job would be weigh modules with a capacity of 100,000 pounds each.

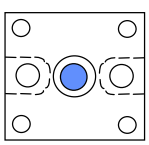
Weigh Module Orientation



FIXED



SEMI-FLOATING



FULL FLOATING

In a typical tank scale application, three or four weigh modules would be used to support the tank. To provide accurate weighing, this system of weigh modules must allow for the thermal expansion and contraction of the tank. A Flexmount HD weigh module system does this by incorporating three different top plate designs:

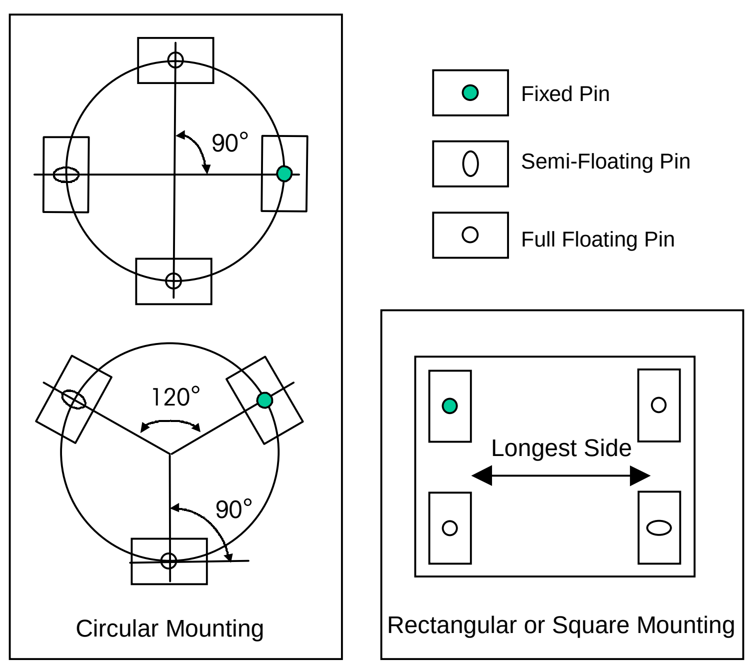
Fixed Pin: The opening in the underside of the top plate is sized to hold the load pin securely. This anchors the weigh module system by providing a fixed point that allows no horizontal movement.

Semi-Floating Pin: The opening in the underside of the top plate is sized to allow the load pin to move in two directions. This accommodates expansion and contraction but keeps the scale from rotating around the fixed pin.

Full-Floating Pin: The opening in the underside of the top plate is sized to allow the load pin to move in any horizontal direction.

An installation should include one fixed-pin weigh module and one semi-floating pin weigh module. The semi-floating pin module should be positioned directly across from the fixed-pin module or at the support location farthest from the fixed-pin module. Full-floating weigh modules should be used at all other support locations. Tank legs or structural support lugs must be rigid enough so that the weight of the full tank does not cause them to spread out.

Recommended mounting arrangements are shown in Figure 7-2.



NOTE: In each of the mounting examples above, the semi-floating module is located and oriented to make full use of its expansion/contraction limits while providing resistance to the rotational moment about the fixed pin. The semi-floating module must be installed in this manner to provide optimum performance and system self-checking.

Figure 7-2: Plan View of Mounting Arrangements

Installation

The actual installation procedure will depend on the specific requirements of an application. One of the first things to consider is the foundation on which the tank scale will be placed. This is usually a concrete floor or steel support structure. Whichever you are using, you will need to make sure that it is strong enough to remain rigid under the weight of the full tank scale. The base plate bearing data in Table 7-1 lists the pressure that each weigh module will exert on its foundation.

0958 Flexmount HD Weigh Module lb	Base Plate Bearing psi (K pascal)	Top Plate Bolts (Metric)	Base Plate Bolts (Metric)
50K	370 (2,551)	1.125″-8 UNC (M30 x 3.5)	1.125″-8 UNC (M30 x 3.5)
75K	556 (3,834)	1.125″-8 UNC (M30 x 3.5)	1.125″-8 UNC (M30 x 3.5)
100K	740 (5,102)	1.125″-8 UNC (M30 x 3.5)	1.125″-8 UNC (M30 x 3.5)
150K	694 (4,785)	1.5″-8 UNC (M40)	1.5″-8 UNC (M40)
200K	926 (6,385)	1.5″-8 UNC (M40)	1.5″-8 UNC (M40)
Bolts should be GR.5 / ASTM A325 minimum			

Table 7-1: Flexmount HD Bearing Support and Mounting Bolt Sizes

General Procedure

1. Position a weigh module under each of the tank's support legs or mounting lugs, and slowly lower the tank onto the weigh modules. The jam nuts and centering washers on each weigh module's hold-down bolts should be tightened against the top plate so that no weight will be placed on the load cell.
2. Make sure that each load point on the tank is well supported by a weigh module's top plate and that all top plates are level within ±1/16 inch. Otherwise, add shims until each load point is supported and the top plates are level.
3. Bolt or weld the top plate of each weigh module to the support leg or mounting lug that is resting on it. For welding use a 3/8-inch fillet, 1 inch long on 3-inch centers.

> ⚠ **CAUTION**
>
> **DO NOT PASS WELDING CURRENT THROUGH THE LOAD CELLS! WHEN WELDING ON A SCALE, ALWAYS GROUND THE WELDING DEVICE AS CLOSE TO THE WORK AS POSSIBLE. NEVER WELD CLOSER THAN 4 FEET (1.2 METERS) TO ANY LOAD CELL WITHOUT REMOVING THE LOAD CELL.**

4. Lower the tank onto the support foundation (concrete slab or support beam). Mark the position of the base plate mounting holes on the foundation (see Figure 7-3). METTLER TOLEDO can supply templates for the bolt holes.

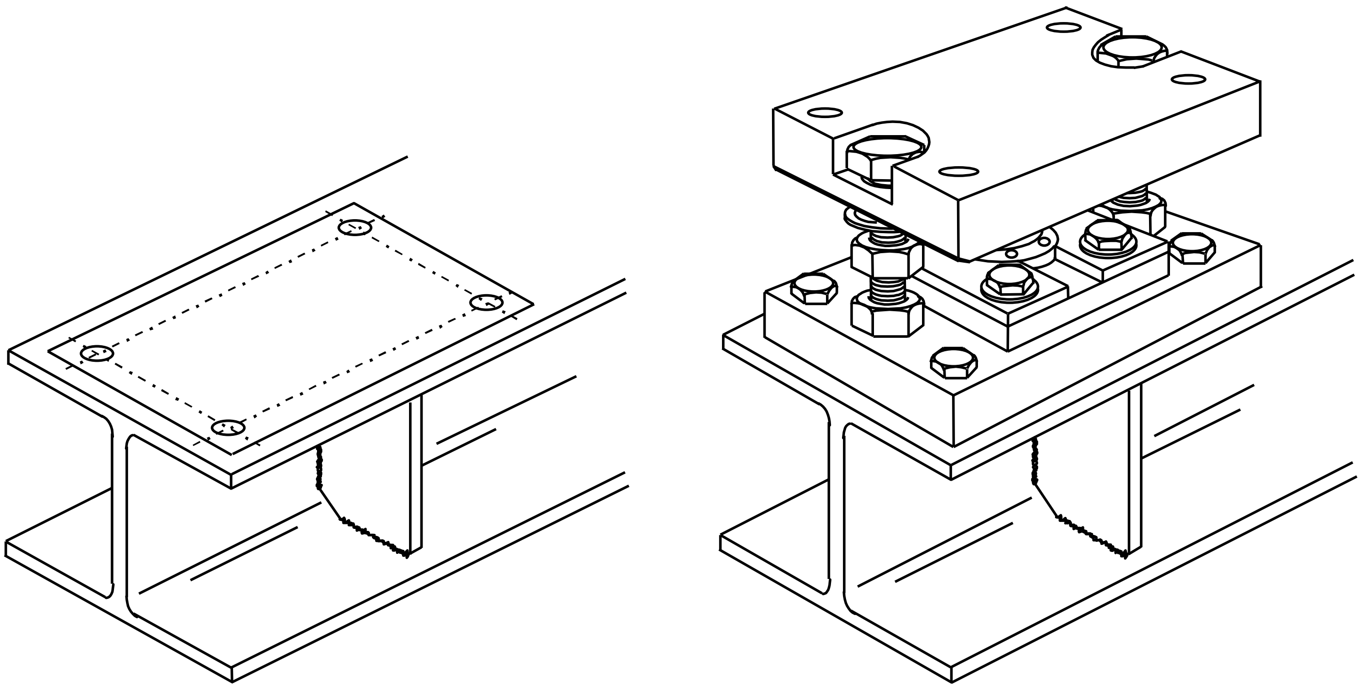
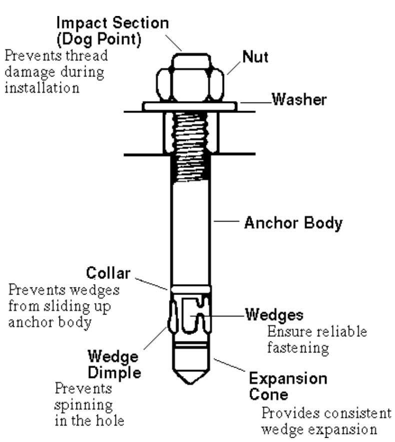


Figure 7-3: Locating Bolt Holes in Support Steel

5. Raise the tank out of the way and drill the appropriate size anchoring holes in the support foundation.
6. Anchor the weigh module base plates to the foundation, using the instructions given below for the appropriate type of foundation. Level each base plate to within ±1/16 inch. All base plates must be in the same level plane within ±1/8 inch.

For a Level Concrete Floor Foundation:
Lower the tank back onto the foundation so that the base plate mounting holes line up with the holes that were drilled in the concrete. Insert a wedge-design expansion anchor bolt into each base plate mounting hole (see Figure 7-4). Follow the anchor bolt manufacturer's instructions regarding the size and depth of holes and recommended torque values.



Expansion Anchor Bolt Detail

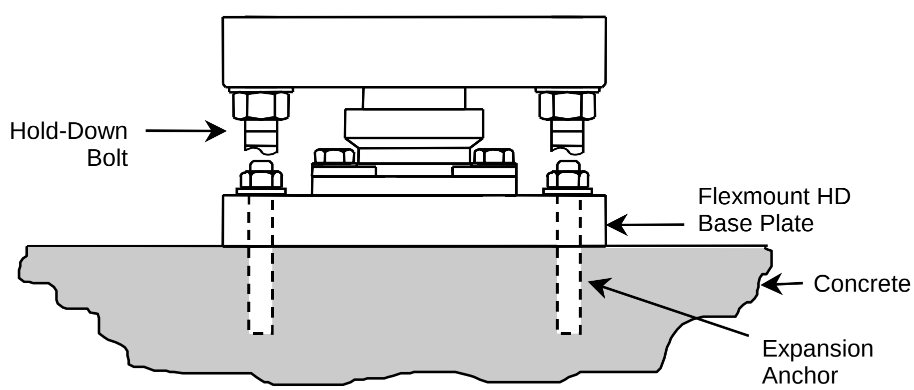


Figure 7-4: Base Plate Bolted to Level Concrete Floor

Note: If you use J-bolt anchors, you will need to place them in the concrete accurately before attaching the weigh modules to the tank supports. Make sure that the tank support holes allow room for adjustment so that the modules can be aligned properly.

For an Unlevel Concrete Floor Foundation:
Install threaded epoxy inserts or J-bolts in the foundation to support the base plates. Place leveling nuts and washers beneath the base plates to adjust for level. Keep the space between each base plate and the concrete floor to a minimum, and fill it with a nonshrink, epoxy grout once all base plates are level and in the same plane (see Figure 7-5).

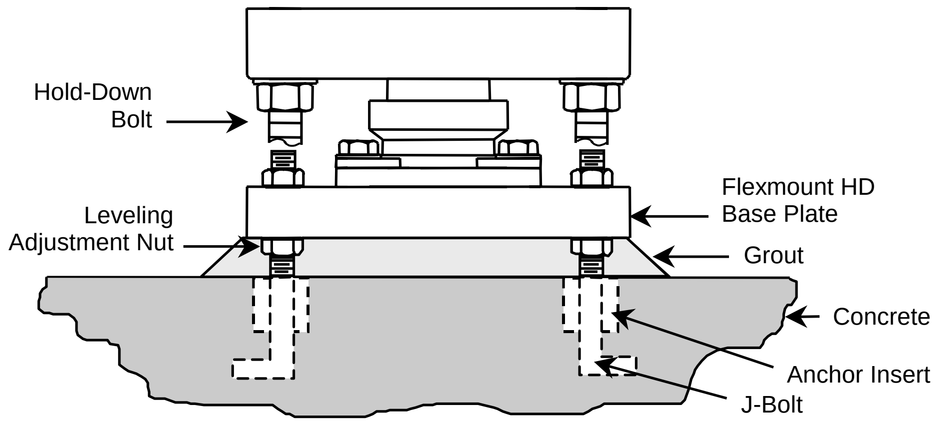


Figure 7-5: Base Plate Bolted to Unlevel Concrete Floor

For a Structural Beam Foundation:
Use through bolts, washers, and nuts to anchor the base plate to the flange of the structural beam (see Figure 7-6). Install web stiffeners to prevent the beam from twisting. If shimming is required to level the base plates or to keep them in the same plane, add the shim beneath the entire base plate. If you are welding the base plates to the beam, use a 3/8-inch fillet, 1 inch long on 3-inch centers.

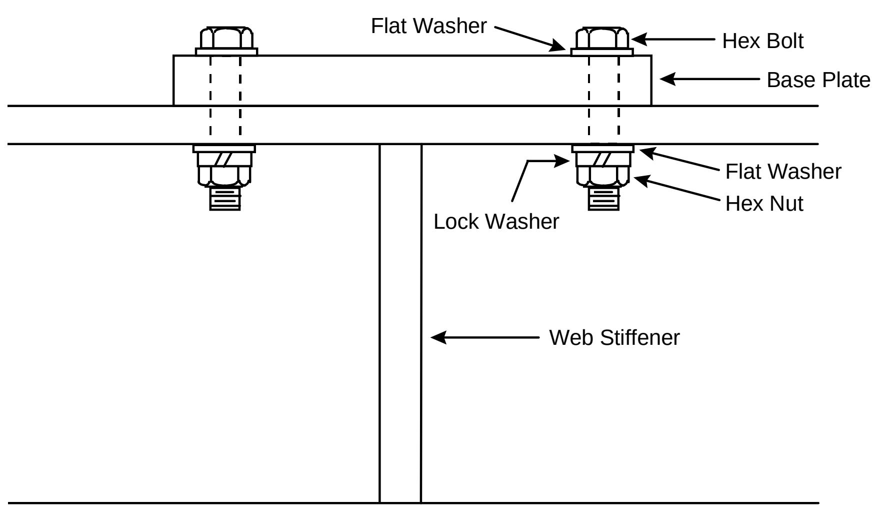


Figure 7-6: Base Plate Bolted to Structural Beam

7. After securing all the top plates and base plates, slowly back out the nut and centering washer on each hold-down bolt, carefully lowering the top plate and weigh structure onto the load cells.

8. After all the top plates are down and applying load to the load cells, make sure there is adequate clearance between the hold-down bolts and retaining holes. See the hold-down bolt assembly shown in Figure 7-7.

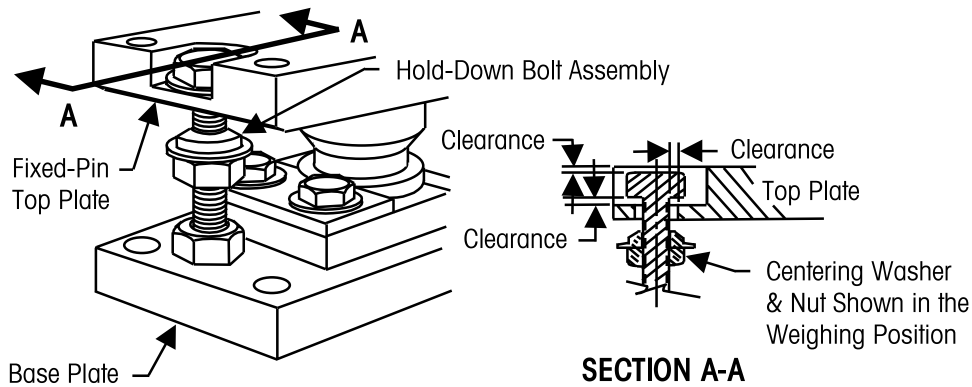


Figure 7-7: Flexmount HD Hold-Down Bolt Assembly

8. Mount the junction box in a location where the load cell cables can be properly terminated in the junction box. Do not mount the junction box on the scale.

   Note: Each load cell is supplied with a standard length of cable. Do not lengthen or shorten load cell cables in the field! Changing the length of a load cell cable will affect the output signal from the load cell. If a cable is too long, simply coil the excess cable and place it in or near the junction box. Nonstandard lengths of cable can be ordered for applications that require them.

9. Connect the load cell cables to the junction box and terminate the wires according to the wiring and color code decal on the underside of the junction box lid.

10. Connect the home run cable from the scale indicator to the junction box.

11. Confirm that all live-to-dead connections (such as piping) are flexible and securely anchored at both the scale and dead connection point.

8

Centerlign Weigh Modules

Centerlign weigh modules are designed for dynamic loading applications such as conveyors, pipe racks, mixers, and blenders. In addition to the load being weighed (vertical force), these weigh modules can handle horizontal forces caused by the sideways movement of the structure that they support. Each weigh module has four basic components, which are shown in Figure 8-1.

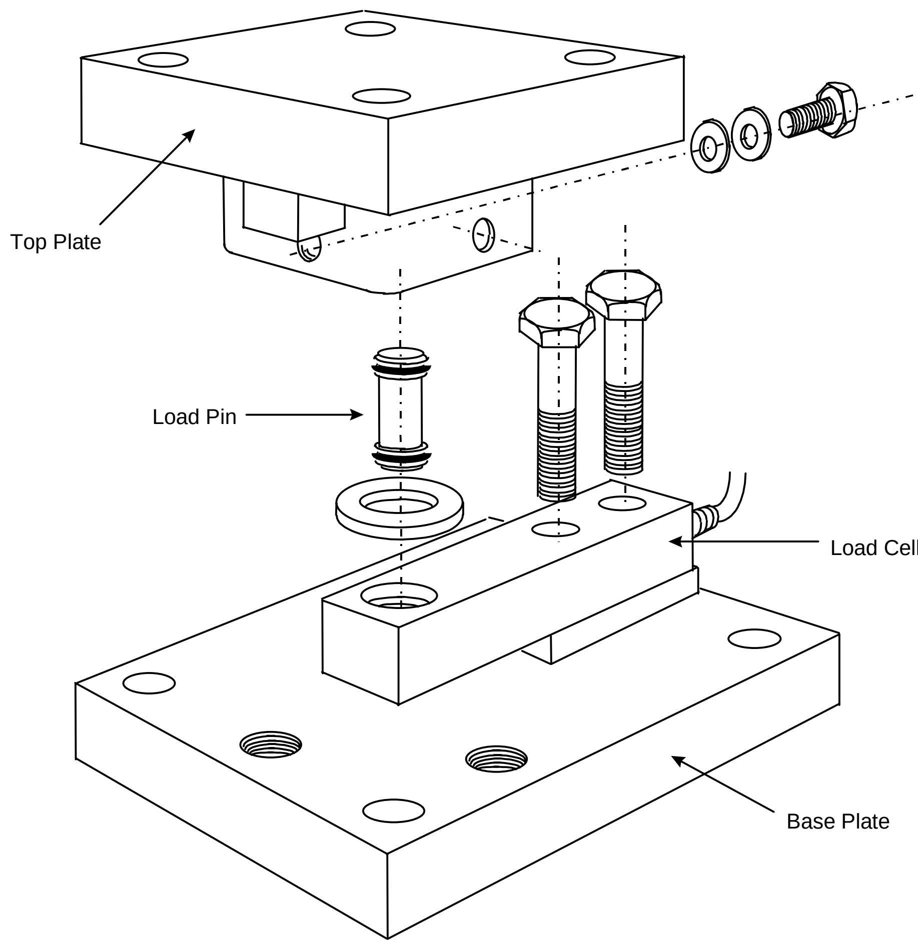


Figure 8-1: Centerlign Weigh Module

Base Plate: This bottom plate is bolted or welded to the floor, foundation, or other support structure to hold the weigh module in place.

Load Cell: This transducer uses a strain gauge to convert the mechanical force exerted by the weight of a tank into an electric signal that provides a weight reading on an indicator. The cantilever-beam load cell is bolted to the weigh module's base plate.

Top Plate: This plate is bolted or welded to a tank or other structure so that it receives the weight of the tank. Adjustable bumper bolts limit the movement of the top plate by bumping against the load cell.

Sizing Weigh Modules

To design a scale that will weigh material accurately, you must use weigh modules with the proper load cell capacity. There are four main factors in sizing Centerlign weigh modules for a scale: (1) the empty weight of the weighbridge on which the material will be placed, (2) the maximum weight of the material to be weighed, (3) the number of support points or weigh modules, and (4) the type of loading. The two types of loading to be considered are full end loading and distributed loading.

To understand the difference between full end loading and distributed loading, imagine a conveyor scale with a weigh module in each of the four corners of its weighbridge. Full end loading can occur when a small object moves across the weighbridge. Initially, the object's full weight will be concentrated on the two weigh modules at the front end of the weighbridge. Only when the object approaches the center of the weighbridge will its weight be distributed evenly across all four weigh modules. Distributed loading occurs when an object with a large surface area moves across the weighbridge. By the time its full weight is on the scale, part of the load has been transferred to the weigh modules at the back end of the weighbridge. With full end loading, you will need to size the weigh modules so that two of them are capable of supporting a full load.

A standard safety factor of 1.25 is normally figured into the calculation to compensate for uneven load distribution and any underestimation of weights. Certain installations might have special environmental considerations requiring additional safety factors. Environmental considerations are discussed in Chapter 4.

Calculating Weigh Module Size

Suppose that you want to size weigh modules for a conveyor section designed to weigh a 3,000-pound billet of aluminum. The conveyor section itself weighs 2,000 pounds and stands on four legs. Since the billet will roll onto the conveyor from one side, the system should be sized for full end loading over two weigh modules. Calculate the total weight of the scale and its contents, figure in any safety factors, and then divide by two weigh modules.

3,000 lb	Weight of billet
+ 1,000 lb	Weight of empty conveyor section (one half)
4,000 lb	Total weight
x 1.25	Safety factor
5,000 lb	Adjusted weight
÷ 2	Number of weigh modules
2,500 lb	Weight per weigh module

Use four 2,500-lb Centerlign weigh modules for this application. If full end loading is not a consideration, divide the adjusted weight by the total number of weigh modules (4) to determine the capacity of weigh modules that will be needed.

Selecting Material

Load cells and other weigh module components can be manufactured of carbon steel or stainless steel. Weigh modules that will be exposed to wet or corrosive environments are generally made of stainless steel. When selecting weigh modules, you will need to consider the environment in which they will be used and the materials that your facility will handle. Appendix 12 provides a chemical resistance chart to aid in selecting materials.

Weigh Module Orientation

Centerlign weigh modules have adjustable bumper bolts built into the underside of the top mounting plate. By bumping against the load cell, these bolts limit a scale's horizontal movement. In a typical application, three or four weigh modules are used to support the tank or other structure. They should always be positioned so that the major horizontal shear force causes the top plates to bump on the end of the load cells. In many four-module systems, two of the modules will have three bolts, with two of the bolts positioned to bump on the sides of the load cells. When only two weigh modules are used for bumpering, both should be located on the same side of the scale. The recommended arrangement of Centerlign weigh modules for a square or rectangular structure is shown in Figure 8-2.

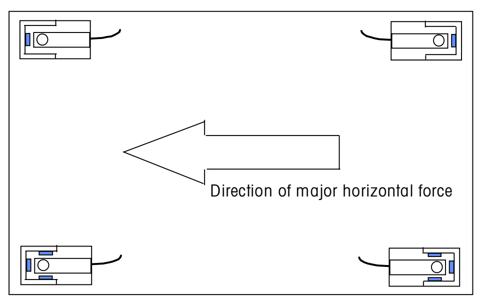


Figure 8-2: Plan View of Square/Rectangular Mounting Arrangements

The recommended arrangement for a mixer or other circular tank with a rotating force is shown in Figure 8-3.

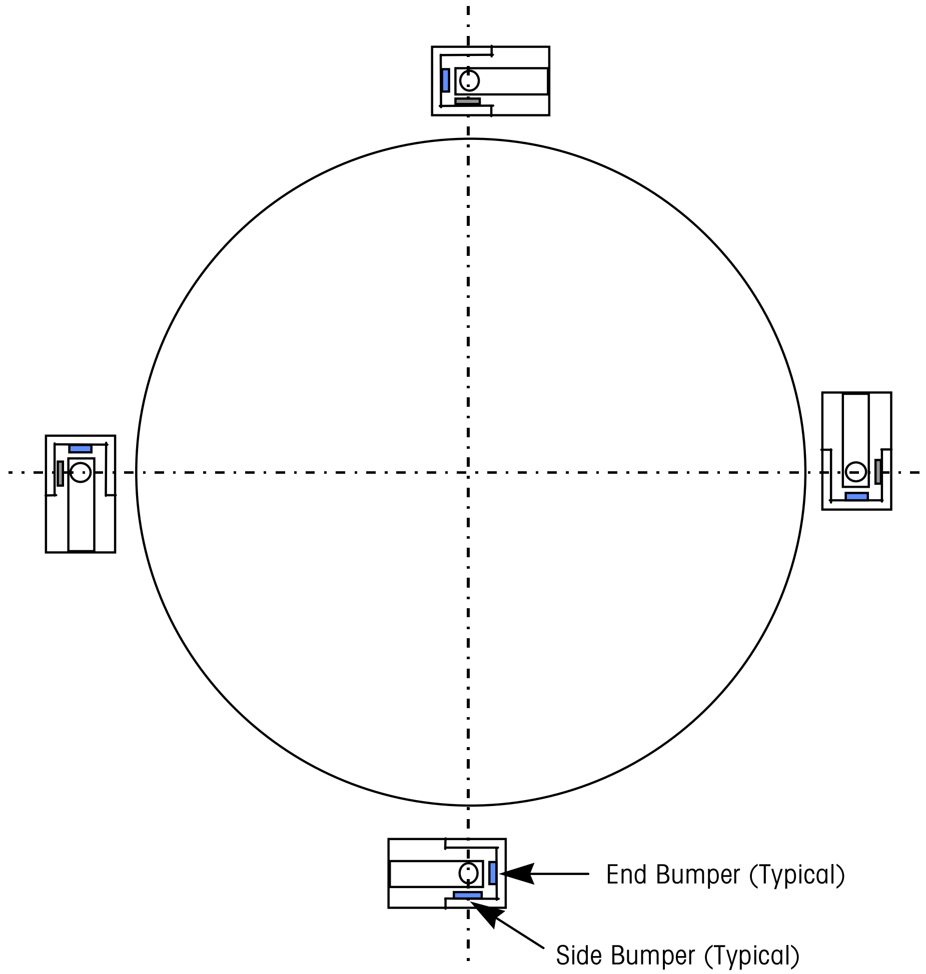


Figure 8-3: Plan View of Circular Mounting Arrangements

Installation

Centerlign weigh modules provide no protection against tipping. To prevent uplift forces from tipping the scale, you should install safety check rods.

The actual installation procedure will depend on the specific requirements of an application. One of the first things to consider is the foundation on which the scale will be placed. This is usually a concrete floor or steel support structure. Whichever you are using, you will need to make sure that it is strong enough to remain rigid under the weight of the full scale. The base plate bearing data in Table 8-1 lists the pressure that each weigh module will exert on its foundation.

⚠ WARNING

CENTERLIGN WEIGH MODULES DO NOT PROVIDE OVERTURN PROTECTION. IF ANY UPLIFT FORCES ARE GENERATED, UPLIFT/OVERTURN PROTECTION MUST BE ADDED SEPARATELY.

⚠ WARNING

STRUCTURES SUCH AS TANKS AND CONVEYORS MUST BE PROPERLY DESIGNED TO MAINTAIN THE RELATIONSHIP OF THE LOAD SUPPORT POINTS THROUGH THE ENTIRE WEIGHING RANGE.

0958 Centerlign Weigh Module lb (kg)	Base Plate Bearing psi (pascal)	Top Plate Bolts (Metric)	Base Plate Bolts (Metric)
250, 500, 1.25K, 2.5K & 5K (220, 550, 1100 & 2200)	159 (1,094,413)	3/8″-16 UNC (M10 x 1.5)	3/8″-16 UNC (M10 x 1.5)
10K (4400)	180 (1,242,306)	5/8″-11 UNC (M16 x 2)	5/8″-11 UNC (M16 x 2)
20K	179 (1,231,214)	3/4″-10 UNC (M20 x 2.5)	3/4″-10 UNC (M20 x 2.5)
30K	268 (1,846,821)	3/4″-10 UNC (M20 x 2.5)	3/4″-10 UNC (M20 x 2.5)
45K	312 (2,154,625)	1″-8 UNC (M24 x 3)	1″-8 UNC (M24 x 3)
Bolts should be GR.5 / ASTM A325 minimum			

Table 8-1: Centerlign Bearing Support and Mounting Bolt Sizes

General Procedure

1. Install an alignment tool in each weigh module. The alignment tool fits between the top plate and the load cell, as shown in Figure 8-4.

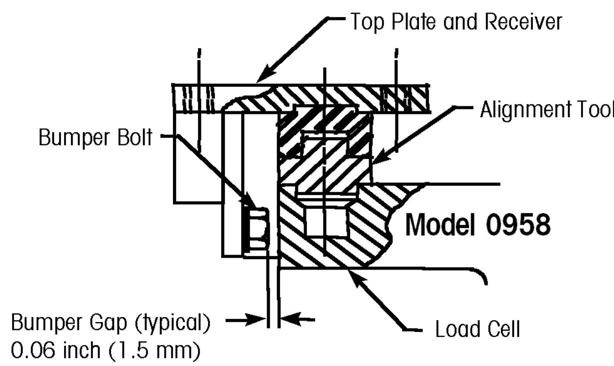


Figure 8-4: Installation of Centerlign Alignment Tools

2. Position a weigh module under each of the weighbridge's support points, and slowly lower the weighbridge onto the weigh modules.
3. Make sure that each load point on the weighbridge is well supported by a weigh module's top plate and that all top plates are level within ±1/16 inch. Otherwise, add shims until each load point is well supported and the top plates are level.
4. Bolt or weld the top plate of each weigh module to the support point of the weighbridge that is resting on it. For welding use a 3/8-inch fillet, 1 inch long on 3-inch centers.

⚠ CAUTION

DO NOT PASS WELDING CURRENT THROUGH THE LOAD CELLS! WHEN WELDING ON A SCALE, ALWAYS GROUND THE WELDING DEVICE AS CLOSE TO THE WORK AS POSSIBLE. NEVER WELD CLOSER THAN 4 FEET (1.2 METERS) TO ANY LOAD CELL WITHOUT REMOVING THE LOAD CELL.

5. Lower the weighbridge onto the support foundation (concrete slab or support beam). Mark the position of the base plate mounting holes on the foundation (see Figure 8-5). METTLER TOLEDO can supply templates for the bolt holes.

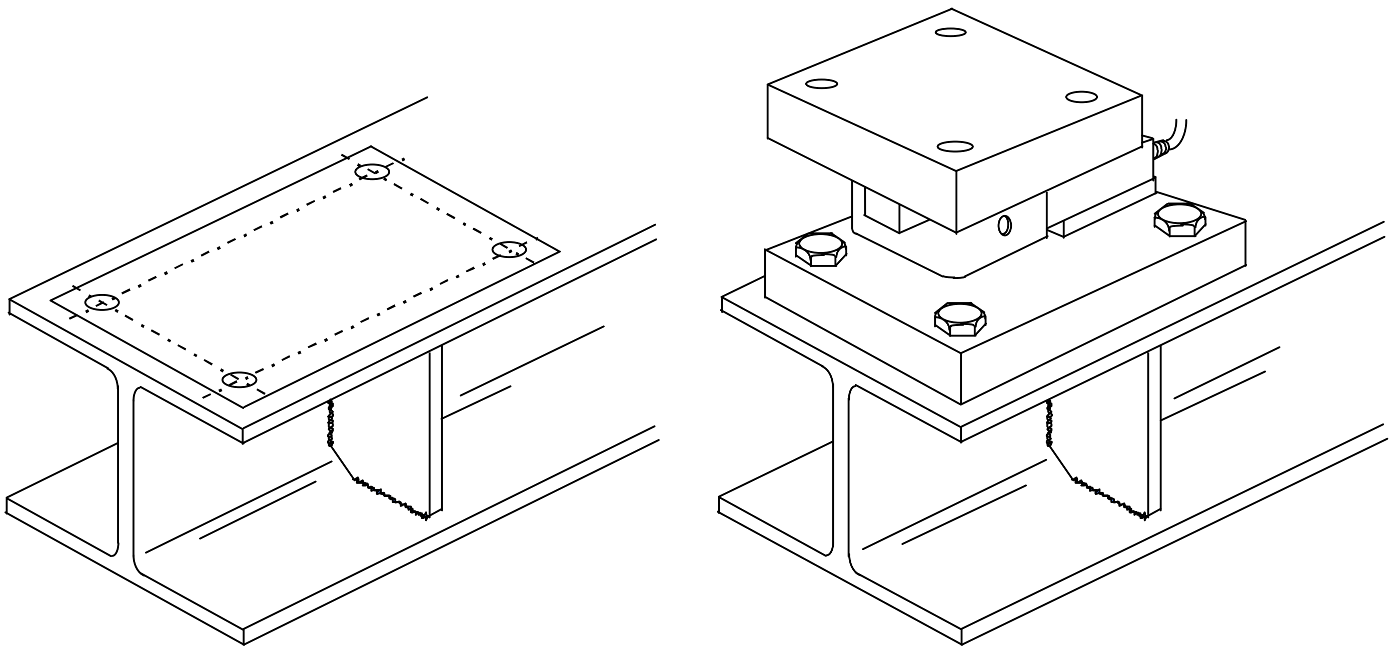
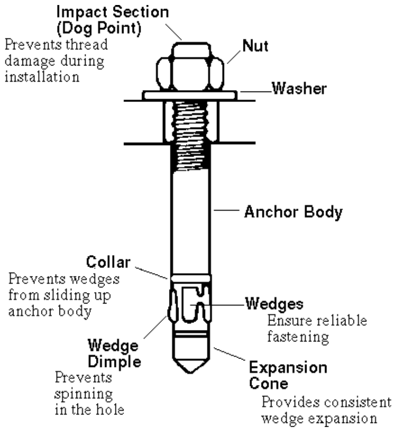


Figure 8-5: Locating Bolt Holes in Support Steel

6. Raise the weighbridge out of the way and drill the appropriate size anchoring holes in the support foundation.
7. Anchor the weigh module base plates to the foundation, using the instructions given below for the appropriate type of foundation. Level each base plate to within ±1/16 inch. All base plates must be in the same level plane within ±1/8 inch.

For a Level Concrete Floor Foundation:
Lower the weighbridge back onto the foundation so that the base plate mounting holes line up with the holes that were drilled in the concrete. Insert a wedge-design expansion anchor bolt into each base plate mounting hole (see Figure 8-6). Follow the anchor bolt manufacturer's instructions regarding the size and depth of holes and recommended torque values.



Expansion Anchor Bolt Detail

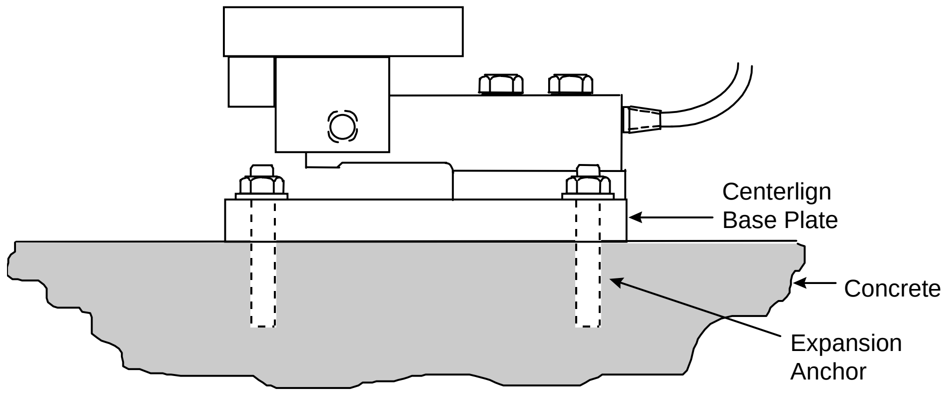


Figure 8-6: Base Plate Bolted to Level Concrete Floor

For an Unlevel Concrete Floor Foundation:
Install threaded epoxy inserts or J-bolts in the foundation to support the base plates. Place leveling nuts and washers beneath the base plates to adjust for level. Keep the space between each base plate and the concrete floor to a minimum, and fill it with a nonshrink, epoxy grout once all base plates are level and in the same plane (see Figure 8-7).

Note: If you use J-bolt anchors, you will need to place them in the concrete accurately before attaching the weigh modules to the weighbridge. Make sure that the holes in the weighbridge's support points allow room for adjustment so that the modules can be aligned properly.

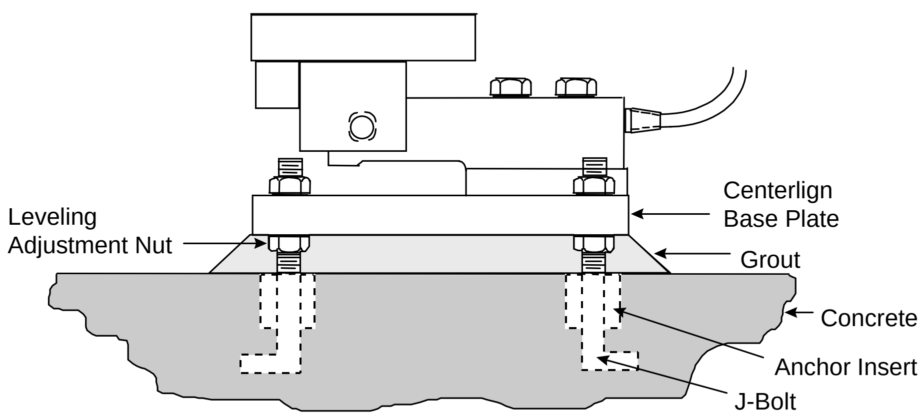


Figure 8-7: Base Plate Bolted to Unlevel Concrete Floor

For a Structural Beam Foundation:
Use through bolts, washers, and nuts to anchor the base plate to the flange of the structural beam (see Figure 8-8). Install web stiffeners to prevent the beam from twisting. If shimming is required to level the base plates or to keep them in the same plane, add the shim beneath the entire base plate. If you are welding the base plates to the beam, use a 3/8-inch fillet, 1 inch long on 3-inch centers.

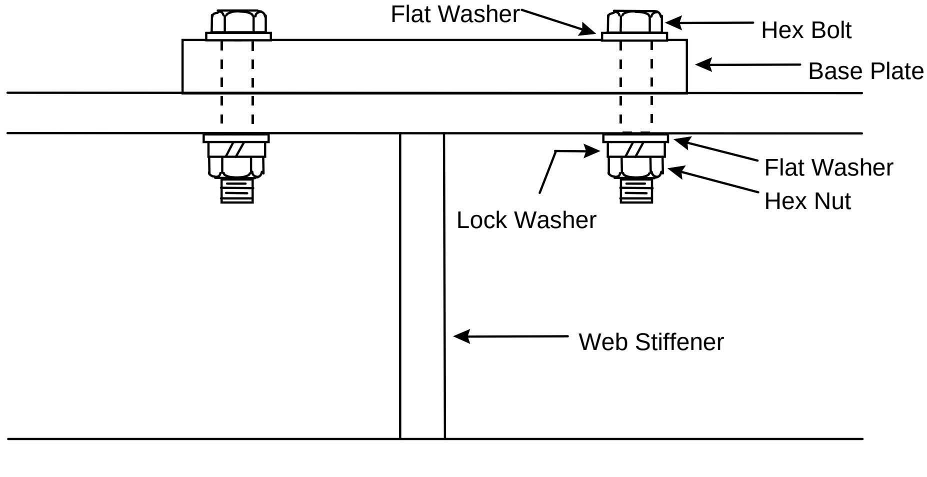


Figure 8-8: Base Plate Bolted to Structural Beam

8. After securing all the top plates and base plates, slowly raise the weighbridge off the lower part of the weigh modules and replace each alignment tool with a rocker pin (see Figure 8-9). Place a rubber O-Ring on each end of each rocker pin. Lubricate the O-Rings and both ends of the rocker pins with a high-quality grease, such as FEL-PRO Food Grade AA Anti-Seize lubricant.

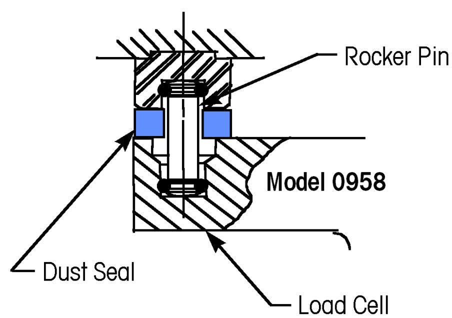


Figure 8-9: Rocker Pin Arrangement for Centerlign Weigh Modules

9. Slowly lower the weighbridge and top plates onto the lower part of the weigh modules. Then apply load to the load cells and move the weighbridge back and forth several times to align and seat all components. Make sure there is adequate clearance between all bumper bolts and load cells. If bumper bolts are not torqued properly, they can back out and bind the scale, leading to weighing inaccuracies.
10. Mount the junction box at a location where the load cell cables can be properly terminated in the junction box. Do not mount the junction box on the scale.

    Note: Each load cell is supplied with a standard length of cable. Do not lengthen or shorten load cell cables in the field! Changing the length of a load cell cable will affect the output signal from the load cell. If a cable is too long, simply coil the excess cable and place it in or near the junction box. Nonstandard lengths of cable can be ordered for applications that require them.
11. Connect the load cell cables to the junction box and terminate the wires according to the wiring and color code decal on the under side the junction box lid.
12. Connect the home run cable from the scale indicator to the junction box.
13. Confirm that all live-to-dead connections (such as piping) are flexible and securely anchored at both the scale and dead connection point.

9 Ultramount Weigh Modules

Ultramount weigh modules (5 to 100 kg) are designed for tanks, hoppers, and vessels with smaller capacities. Two options are available for transferring weight from the top plate to the load cell: a load pin for static loading applications such as tanks and a ball-and-cup assembly for dynamic loading applications such as conveyors. All Ultramount assemblies use stainless steel components and hardware. Each weigh module has five basic components, which are shown in Figure 9-1.

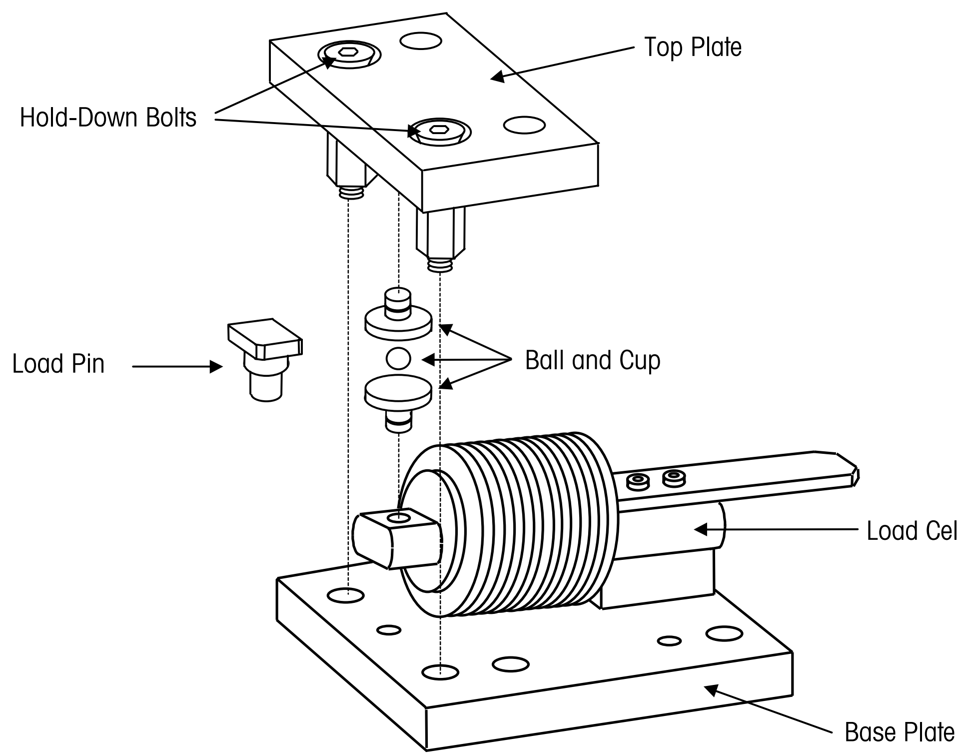


Figure 9-1: Ultramount Weigh Module

Base Plate: This bottom plate is bolted or welded to the floor, foundation, or other support structure to hold the weigh module in place.

Load Cell: This transducer uses a strain gauge to convert the mechanical force exerted by the weight of a tank into an electric signal that provides a weight reading on an indicator. The load cell is bolted to the weigh module's base plate.

Load Pin: This pin fits into an opening in the underside of the top plate. It is used in static loading applications to transfer weight from the top plate to a single point on the load cell.

Ball and Cup: This assembly consists of upper and lower cups with a ball bearing between them. It is used in dynamic loading applications to transfer weight from the top plate to a single point on the load cell.

Top Plate: This plate is bolted or welded to a tank or other structure so that it receives the weight of the tank.

Hold-Down Bolts: These bolts connect the top plate to the base plate in order to check any uplift forces that might cause the tank scale to tip. Clearance must be maintained between the bolt and the top plate so that the bolt does not receive any of the weight that is being transferred to the load pin or ball-and-cup assembly.

Sizing Weigh Modules

To design a scale that will weigh accurately, you must use weigh modules with the proper load cell capacity. There are three main factors in sizing weigh modules for a tank scale: (1) the weight of the empty tank, (2) the weight of the tank's contents when full, and (3) the number of weigh modules. The number of weigh modules will equal the number of legs or supports that the tank has.

A standard safety factor of 1.25 is normally figured into the calculation to compensate for uneven load distribution and any underestimation of weights. Certain installations might have special environmental considerations requiring additional safety factors. Environmental considerations are discussed in Chapter 4.

Calculating Weigh Module Size

Suppose that you want to add Ultramount weigh modules to a tank designed to hold 100 kilograms of a liquid. The tank itself weighs 50 kilograms and stands on four legs. Assume that only the standard safety factor is needed for this installation. To determine what size weigh modules you will need, calculate the total weight of the tank and its contents, figure in any safety factors, and then divide by the number of weigh modules.

100 kg	Weight of liquid
+ 50 kg	Weight of empty tank
150 kg	Total weight
x 1.25	Safety factor
187.5 kg	Adjusted weight
÷ 4	Number of weigh modules
46.875 kg	Weight per weigh module

Since each weigh module will need to handle up to 46.875 kilograms, the best choice for the job would be weigh modules with a capacity of 50 kilograms each.

If you are designing an Ultramount weigh module system for a dynamic loading application such as a conveyor scale, you will need to consider four factors: (1) the empty weight of the weighbridge on which the material will be placed, (2) the maximum weight of the material to be weighed, (3) the number of support points or weigh modules, and (4) the type of loading–full end loading or distributed loading. With full end loading, you will need to size the weigh modules so that two of them are capable of supporting a full load.

To calculate weigh module size for a conveyor scale with four support points, add the maximum weight of the material to be weighed and the weight of the weighbridge. Then multiply this total weight by a safety factor to determine an adjusted weight. If full end loading is a factor, divide the adjusted weight by 2 (the smallest number of weigh modules that will need to support the full load) to determine the capacity of weigh modules that will be needed. If full end loading is not a consideration, divide the adjusted weight by 4 (the total number of weigh modules).

Weigh Module Orientation

In a typical tank scale application, three or four weigh modules would be used to support the tank. Ultramount weigh modules can be oriented for tangential or radial mounting as shown in Figure 9-2.

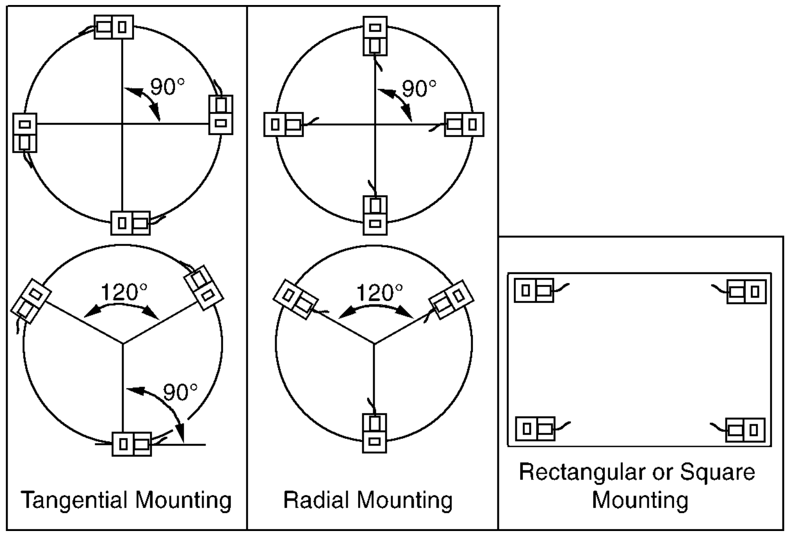


Figure 9-2: Plan View of Mounting Arrangements

Installation

The actual installation procedure will depend on the specific requirements of an application. One of the first things to consider is the foundation on which the scale will be placed. This is usually a concrete floor or steel support structure. Whichever you are using, you will need to make sure that it is strong enough to remain rigid under the weight of the full scale. The base plate bearing data in Table 9-1 lists the pressure that each weigh module will exert on its foundation.

0972 Ultramount Weigh Module kg	Base Plate Bearing psi (K pascal)	Top Plate Bolts (Metric)	Base Plate Bolts (Metric)
5	0.5 (3.66)	(M12 x 1.75)	(M10 x 1.5)
10	1.0 (7.32)	(M12 x 1.75)	(M10 x 1.5)
20	2.1 (14.65)	(M12 x 1.75)	(M10 x 1.5)
50	5.3 (36.62)	(M12 x 1.75)	(M10 x 1.5)
100	10.6 (73.23)	(M12 x 1.75)	(M10 x 1.5)
Bolts should be GR.5 / ASTM A325 minimum			

Table 9-1: Ultramount Bearing Support and Mounting Bolt Sizes

General Procedure

1. Position a weigh module under each of the weigh structure's support points, and slowly lower the weigh structure onto the weigh modules. The jam nuts on the hold-down bolts should be tightened until the top plate is tight against the heads of the bolts, so that no weight will be placed on the load cell when you lower the weigh structure.
2. Make sure that each load point on the weigh structure is well supported by the module's top plate, and that all top plates are level within ±1/32 inch (0.8 mm). Otherwise, add shims until each load point is supported and the top plate is level.
3. Bolt or weld the top plate of each weigh module to the support point of the weigh structure that is resting on it. For bolting the top plates, use two M12 x 1.75 screws or 3/8-16 UNC bolts and nuts. For welding use a 3/16-inch fillet, 1 inch long on 3-inch centers.

> ⚠ **CAUTION**
>
> **DO NOT PASS WELDING CURRENT THROUGH THE LOAD CELLS! WHEN WELDING ON A SCALE, ALWAYS GROUND THE WELDING DEVICE AS CLOSE TO THE WORK AS POSSIBLE. NEVER WELD CLOSER THAN 4 FEET (1.2 METERS) TO ANY LOAD CELL WITHOUT REMOVING THE LOAD CELL.**

4. Lower the weigh structure onto the support foundation (concrete slab or support beam). Mark the position of the base plate mounting holes on the foundation (see Figure 9-3). METTLER TOLEDO can supply templates for the bolt holes.

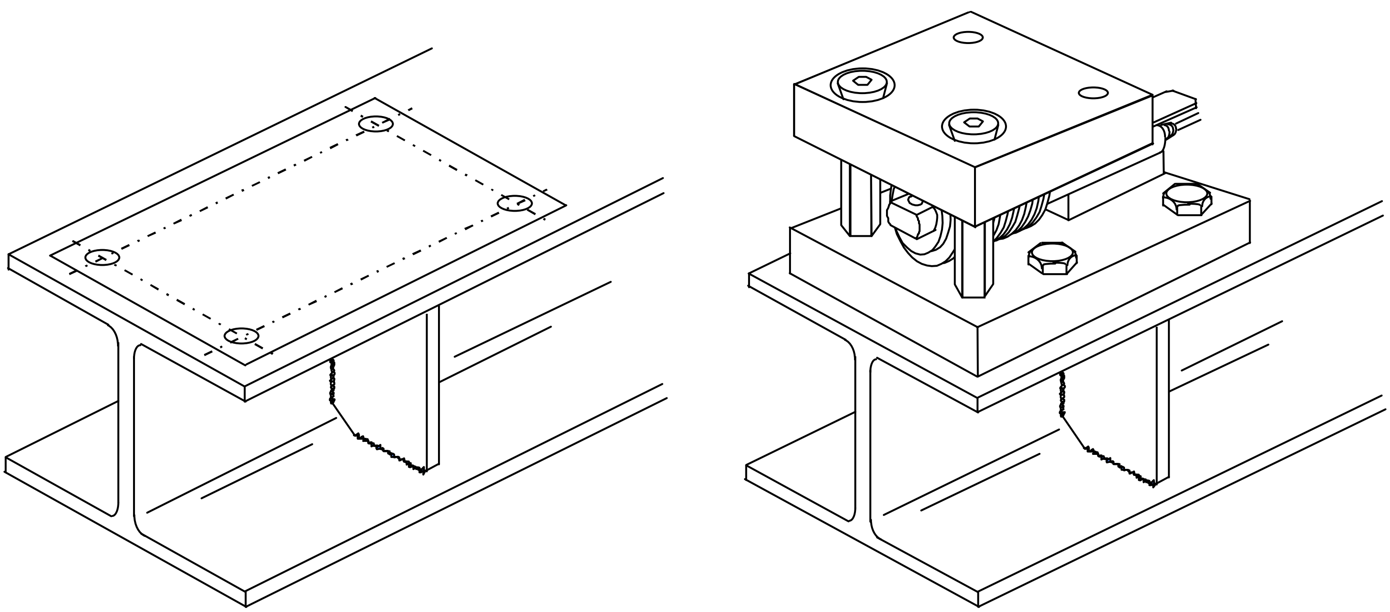
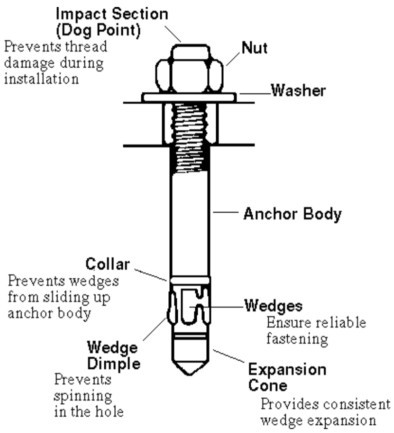


Figure 9-3: Locating Bolt Holes in Support Steel

5. Raise the weigh structure out of the way and drill the appropriate size anchoring holes in the support foundation.
6. Anchor the weigh module base plates to the foundation, using the instructions given below for the appropriate type of foundation. Level each base plate to within ±1/16 inch. All base plates must be in the same level plane within ±1/8 inch.

For a Level Concrete Floor Foundation:
Lower the weigh structure back onto the foundation so that the base plate mounting holes line up with the holes that were drilled in the concrete. Insert a wedge-design expansion anchor bolt into each base plate mounting hole (see Figure 9-4). Follow the anchor bolt manufacturer's instructions regarding the size and depth of holes and recommended torque values.



Expansion Anchor Bolt Detail

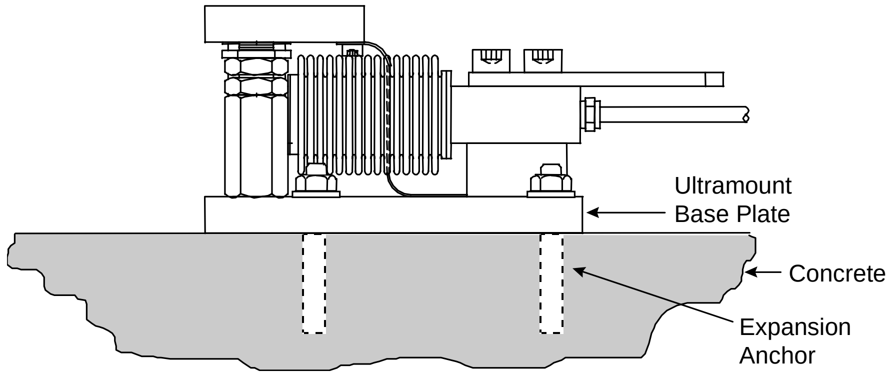


Figure 9-4: Base Plate Bolted to Level Concrete Floor

For an Unlevel Concrete Floor Foundation:
Install threaded epoxy inserts or J-bolts in the foundation to support the base plates. Place leveling nuts and washers beneath the base plates to adjust for level. Keep the space between each base plate and the concrete floor to a minimum, and fill it with a nonshrink, epoxy grout once all base plates are level and in the same plane (see Figure 9-5).

Note: If you use J-bolt anchors, you will need to place them in the concrete accurately before attaching the weigh modules to the weigh structure supports. Make sure that the weigh structure support holes allow room for adjustment so that the modules can be aligned properly.

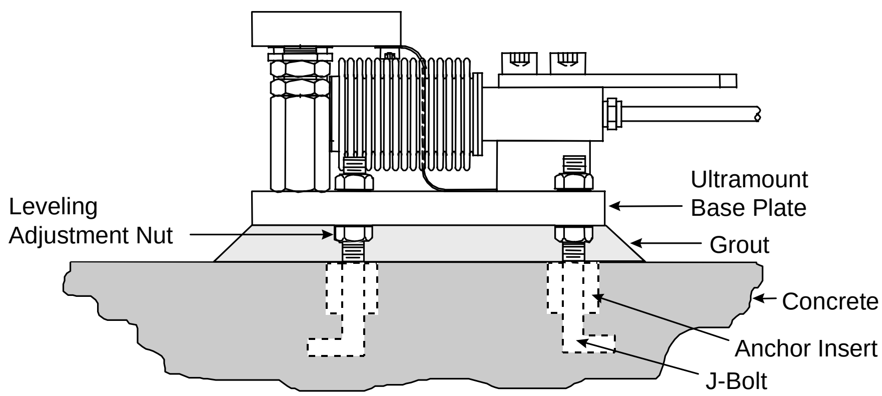


Figure 9-5: Base Plate Bolted to Unlevel Concrete Floor

For a Structural Beam Foundation:
Use through bolts, washers, and nuts to anchor the base plate to the flange of the structural beam (see Figure 9-6). Install web stiffeners to prevent the beam from twisting. If shimming is required to level the base plates or to keep them in the same plane, add the shim beneath the entire base plate. For bolting the base plates, use four M10 or 3/8-16 UNC anchor bolts. For welding the base plates to the beam, use a 3-inch fillet, 1 inch long on 3-inch centers.

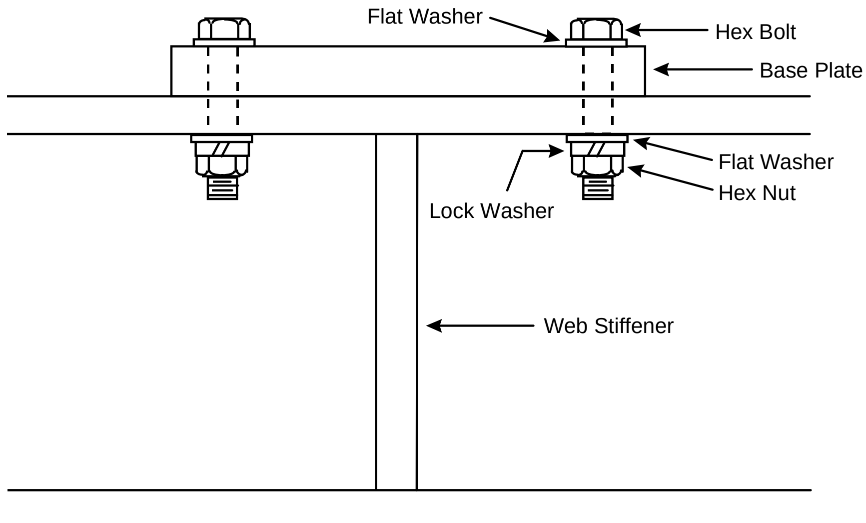


Figure 9-6: Base Plate Bolted to Structural Beam

6. After securing all the top plates and base plates, slowly back out the nut and centering washer on each hold-down bolt, carefully lowering the top plate and weigh structure onto the load cells.
7. After all the top plates are down and applying load to the load cells, make sure there is adequate clearance between the hold-down bolts and retaining holes. See Figure 9-7 and Figure 9-8.

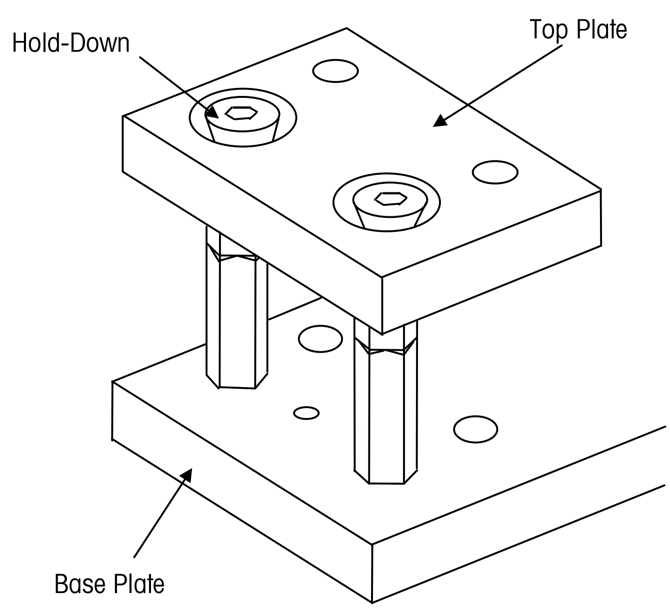


Figure 9-7: Hold-Down Bolt Assembly

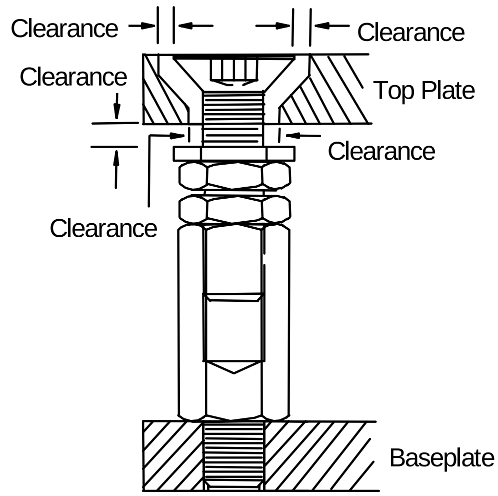


Figure 9-8: Hold-Down Bolt Assembly (Cross Section)

9. Mount the junction box in a location where the load cell cables can be properly terminated in the junction box. Do not mount the junction box on the scale.

   Note: Each load cell is supplied with a standard length of cable. Do not lengthen or shorten load cell cables in the field! Changing the length of a load cell cable will affect the output signal from the load cell. If a cable is too long, simply coil the excess cable and place it in or near the junction box. Nonstandard lengths of cable can be ordered for applications that require them.

10. Connect the load cell cables to the junction box and terminate the wires according to the wiring and color code decal on the underside of the junction box lid.
11. Connect the home run cable from the scale indicator to the junction box.
12. Confirm that all live-to-dead connections (such as piping) are flexible and securely anchored at both the scale and the dead connection point.

10 Value Line Weigh Modules

Value Line weigh modules are designed for general purpose applications such as OEM machinery, conveyors, and tanks and hoppers with very flexible inlets/outlets. Typically, the only force that needs to be considered is the weight of the tank and its contents (the vertical force pressing down on the top plate of the weigh module). Each weigh module has three basic components, which are shown in Figure 10-1.

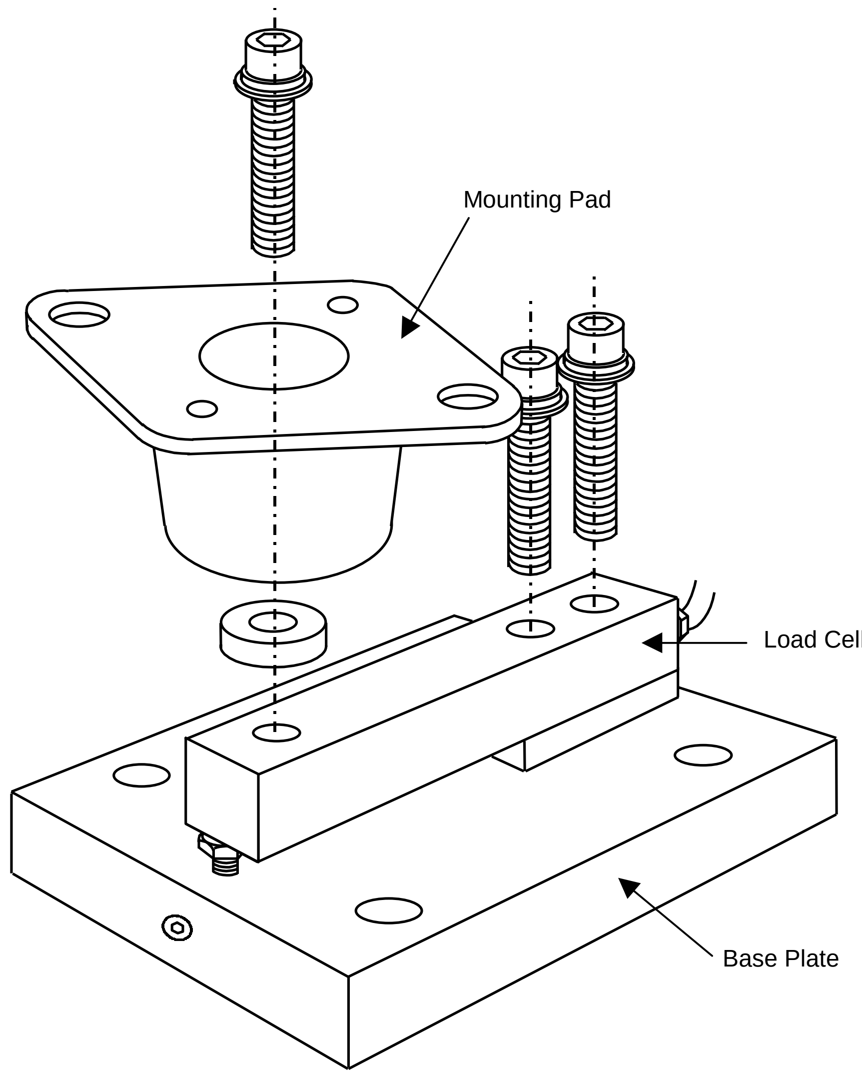


Figure 10-1: Value Line Weigh Module

Base Plate: This bottom plate is bolted or welded to the floor, foundation, or other support structure to hold the weigh module in place.

Load Cell: This transducer uses a strain gauge to convert the mechanical force exerted by the weight of a tank into an electric signal that provides a weight reading on an indicator. The cantilever-beam load cell is bolted to the weigh module's base plate.

Mounting Pad: This pad is bolted to a tank or other structure so that it receives the weight of the tank.

Sizing Weigh Modules

To design a tank scale that will weigh its contents accurately, you must use weigh modules with the proper load cell capacity. There are three main factors in sizing weigh modules for a tank scale: (1) the weight of the empty tank, (2) the weight of the tank's contents when full, and (3) the number of weigh modules. The number of weigh modules will equal the number of legs or supports that the tank has.

A standard safety factor of 1.25 is normally figured into the calculation to compensate for uneven load distribution and any underestimation of weights. Certain installations might have special environmental considerations requiring additional safety factors. Environmental considerations are discussed in Chapter 4.

Calculating Weigh Module Size

Suppose that you want to add weigh modules to a tank designed to hold 2,000 pounds of a liquid. The tank itself weighs 1,000 pounds and stands on four legs. Assume that only the standard safety factor is needed for this installation. To determine what size weigh modules you will need, calculate the total weight of the tank and its contents, figure in any safety factors, and then divide by the number of weigh modules.

2,000 lb	Weight of liquid
+1,000 lb	Weight of empty tank
3,000 lb	Total weight
x 1.25	Safety factor
3,750 lb	Adjusted weight
÷ 4	Number of weigh modules
937.5 lb	Weight per weigh module

Since each weigh module will need to handle up to 937.5 pounds, the best choice for the job would be weigh modules with a capacity of 1,000 pounds each.

If you are designing a Value Line weigh module system for a dynamic loading application such as a conveyor scale, you will need to consider four factors: (1) the empty weight of the weighbridge on which the material will be placed, (2) the maximum weight of the material to be weighed, (3) the number of support points or weigh modules, and (4) the type of loading–full end loading or distributed loading. With full end loading, you will need to size the weigh modules so that two of them are capable of supporting a full load.

To calculate weigh module size for a conveyor scale with four support points, add the maximum weight of the material to be weighed and the weight of the weighbridge. Then multiply this total weight by a safety factor to determine an adjusted weight. If full end loading is a factor, divide the adjusted weight by 2 (the smallest number of weigh modules that will need to support the full load) to determine the capacity of weigh modules that will be needed. If full end loading is not a consideration, divide the adjusted weight by 4 (the total number of weigh modules).

Applications should have minimal side load or shear.

Weigh Module Orientation

In a typical tank scale application, three or four weigh modules would be used to support the tank. Space the weigh modules evenly, so that each one supports approximately the same amount of weight.

Recommended mounting arrangements are shown in Figure 10-2.

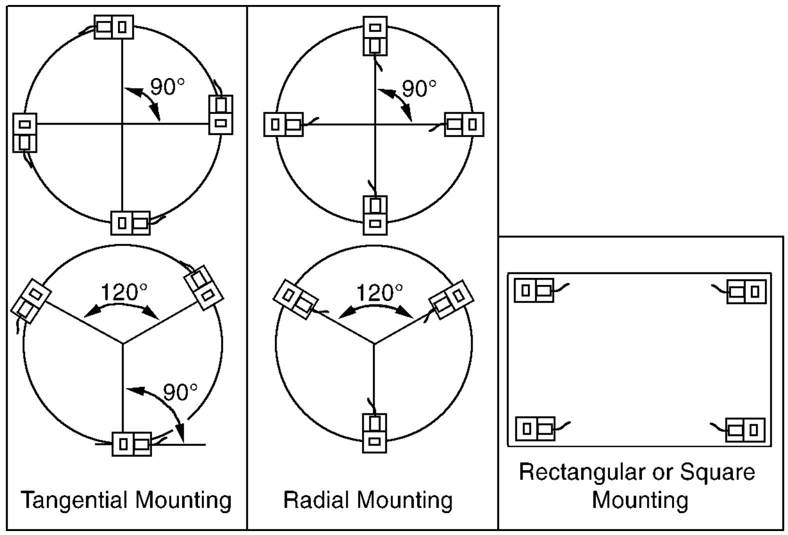


Figure 10-2: Plan View of Mounting Arrangements

Installation

The actual installation procedure will depend on the specific requirements of an application. One of the first things to consider is the foundation on which the tank scale will be placed. This is usually a concrete floor or steel support structure. Whichever you are using, you will need to make sure that it is strong enough to remain rigid under the weight of the full tank scale. The base plate bearing data in Table 10-1 lists the pressure that each weigh module will exert on its foundation.

VLM2 Value Line Weigh Module lb	Base Plate Bearing psi (K pascal)	Top Plate Bolts (Metric)	Base Plate Bolts (Metric)
250	11 (76)	1/4″-20 UNC (M6 x 1)	3/8″-16 UNC (M10 x 1.5)
500	21 (145)	1/2″-13 UNC (M12 x 1.75)	3/8″-16 UNC (M10 x 1.5)
1,000	42 (290)	3/8″-16 UNC (M10 x 1.5)	3/8″-16 UNC (M10 x 1.5)
2,000	84 (579)	1/2″-13 UNC (M12 x 1.75)	3/8″-16 UNC (M10 x 1.5)
2,500	104 (717)	1/2″-13 UNC (M12 x 1.75)	3/8″-16 UNC (M10 x 1.5)
Bolts should be GR.5 / ASTM A325 minimum			

Table 10-1: Value Line Bearing Support and Mounting Bolt Sizes

General Procedure

1. Position a weigh module under each of the tank's support legs or mounting lugs, and slowly lower the tank onto the weigh modules.
2. Make sure that each load point on the tank is well supported by a weigh module's mounting pad and that all mounting pads are level within ±1/16 inch. Otherwise, add shims until each load point is supported and the mounting pads are level.
3. Bolt the mounting pad of each weigh module to the support leg or mounting lug that is resting on it.
4. Lower the tank onto the support foundation (concrete slab or support beam). Mark the position of the base plate mounting holes on the foundation (see Figure 10-3). METTLER TOLEDO can supply templates for the bolt holes.

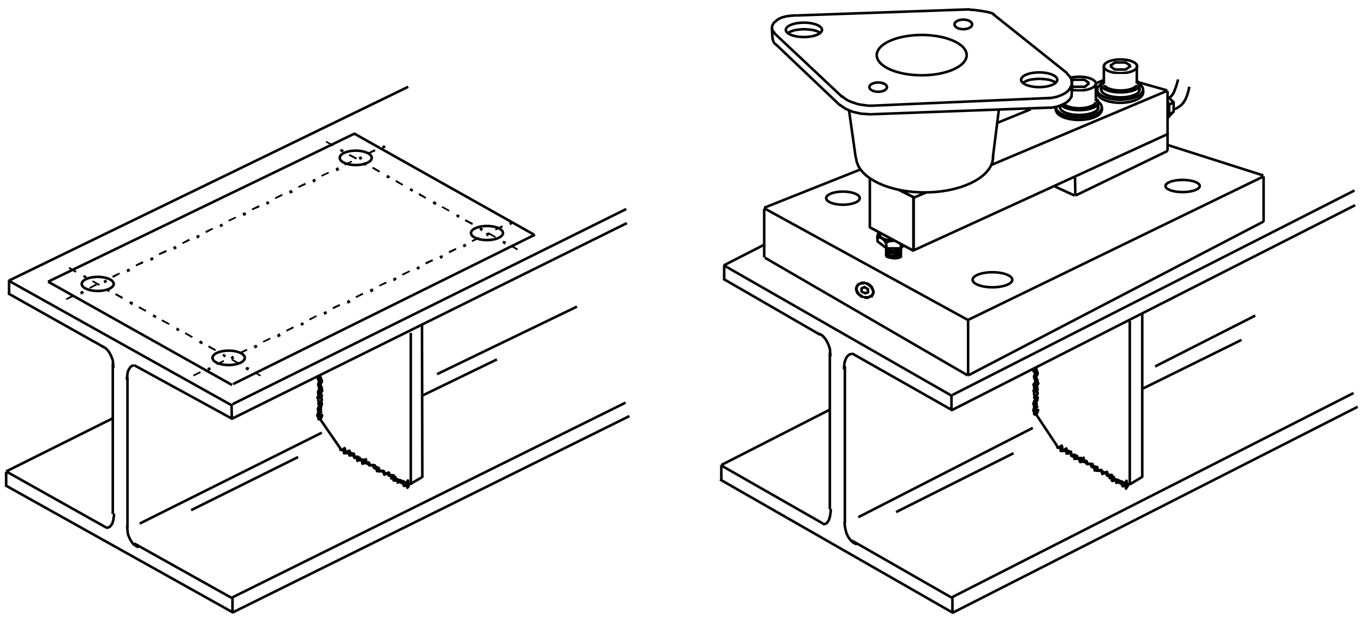
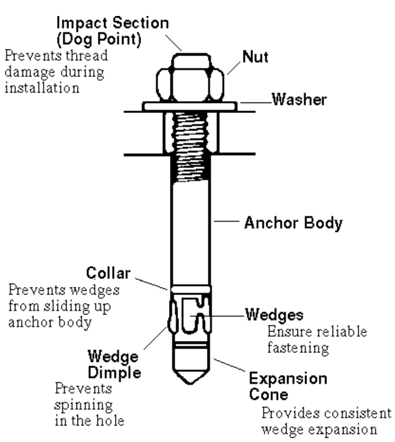


Figure 10-3: Locating Bolt Holes in Support Steel

5. Raise the tank out of the way and drill the appropriate size anchoring holes in the support foundation.
6. Anchor the weigh module base plates to the foundation, using the instructions given below for the appropriate type of foundation. Level each base plate to within ±1/16 inch. All base plates must be in the same level plane within ±1/8 inch.

For a Level Concrete Floor Foundation:
Lower the tank back onto the foundation so that the base plate mounting holes line up with the holes that were drilled in the concrete. Insert a wedge-design expansion anchor bolt into each base plate mounting hole (see Figure 10-4). Follow the anchor bolt manufacturer's instructions regarding the size and depth of holes and recommended torque values.



Expansion Anchor Bolt Detail

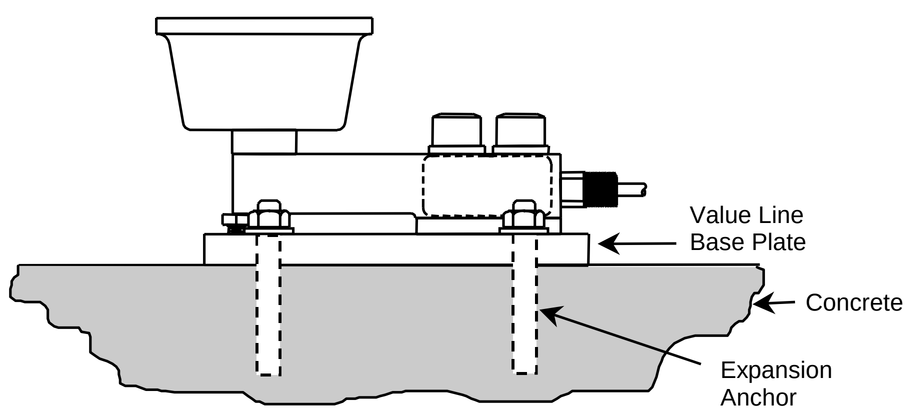


Figure 10-4: Base Plate Bolted to Level Concrete Floor

Note: If you use J-bolt anchors, you will need to place them in the concrete accurately before attaching the weigh modules to the tank supports. Make sure that the tank support holes allow room for adjustment so that the modules can be aligned properly.

For an Unlevel Concrete Floor Foundation:
Install threaded epoxy inserts or J-bolts in the foundation to support the base plates. Place leveling nuts and washers beneath the base plates to adjust for level. Keep the space between each base plate and the concrete floor to a minimum, and fill it with a nonshrink, epoxy grout once all base plates are level and in the same plane (see Figure 10-5).

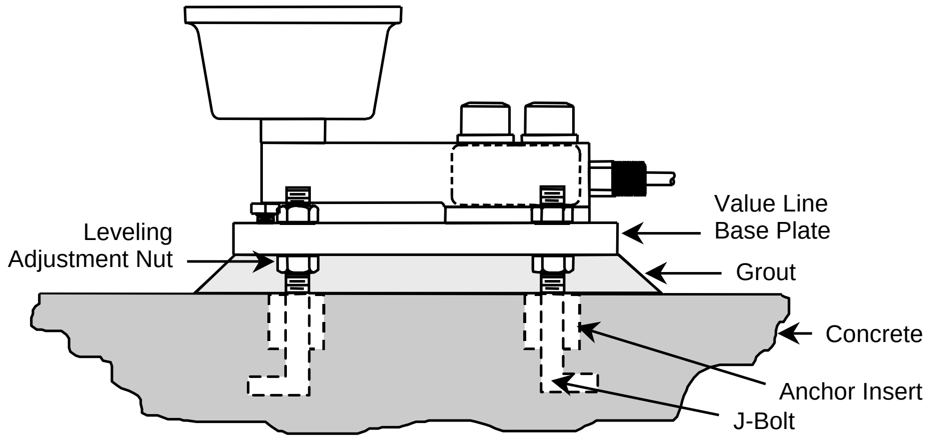


Figure 10-5: Base Plate Bolted to Unlevel Concrete Floor

For a Structural Beam Foundation:
Use through bolts, washers, and nuts to anchor the base plate to the flange of the structural beam (see Figure 10-6). Install web stiffeners to prevent the beam from twisting. If shimming is required to level the base plates or to keep them in the same plane, add the shim beneath the entire base plate. If you are welding the base plates to the beam, use a 3/8-inch fillet, 1 inch long on 3-inch centers.

⚠ CAUTION

DO NOT PASS WELDING CURRENT THROUGH THE LOAD CELLS! WHEN WELDING ON A SCALE, ALWAYS GROUND THE WELDING DEVICE AS CLOSE TO THE WORK AS POSSIBLE. NEVER WELD CLOSER THAN 4 FEET (1.2 METERS) TO ANY LOAD CELL WITHOUT REMOVING THE LOAD CELL.

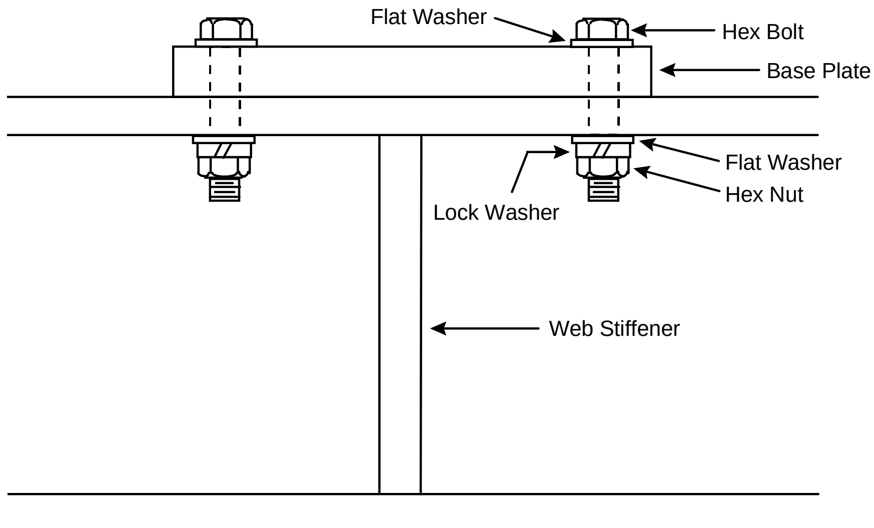


Figure 10-6: Base Plate Bolted to Structural Beam

7. Mount the junction box in a location where the load cell cables can be properly terminated in the junction box. Do not mount the junction box on the scale.

   Note: Each load cell is supplied with a standard length of cable. Do not lengthen or shorten load cell cables in the field! Changing the length of a load cell cable will affect the output signal from the load cell. If a cable is too long, simply coil the excess cable and place it in or near the junction box. Nonstandard lengths of cable can be ordered for applications that require them.

8. Connect the load cell cables to the junction box and terminate the wires according to the wiring and color code decal on the underside of the junction box lid.
9. Connect the home run cable from the scale indicator to the junction box.
10. Confirm that all live-to-dead connections (such as piping) are flexible and securely anchored at both the scale and dead connection point.

11 Tension Weigh Modules

Tension weigh modules are designed for applications that require a tank, hopper, or other structure to be suspended. They are installed as part of the suspension system, so that the full weight of the hopper and its contents hangs from the weigh modules. Tension weigh modules can also be used to convert mechanical level scales for electronic weighing. Each weigh module has the basic components shown in Figure 11-1.

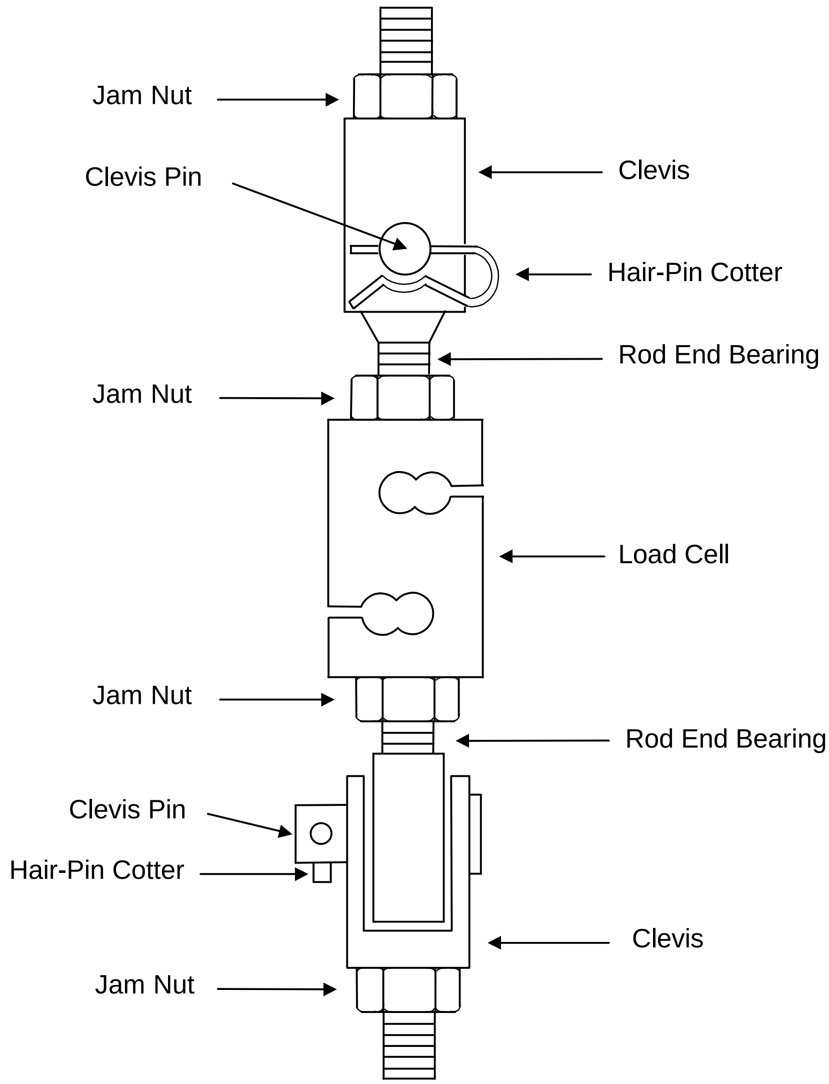


Figure 11-1: Tension Weigh Module

Load Cell: This S-beam load cell uses a strain gauge to convert the mechanical force exerted by the weight of a hopper into an electric signal that provides a weight reading on an indicator. Both the top and bottom of the load cell have an opening designed to accept a threaded rod.

Spherical Rod End Bearing: For tank or hopper scale applications, a threaded rod end bearing is screwed into the opening on each end of the load cell. These two bearings are positioned so that one is turned at 90 degrees from the other.

Clevis/Pin Assembly: A U-shaped clevis is connected to each rod end bearing with a clevis pin. This assembly forms a ball joint that rotates to compensate for when a weigh module suspension system is not perfectly vertical. A hitch pin is used to lock each clevis pin into place.

Jam Nuts: These four nuts are tightened to hold the threaded components in place, preventing the weight of the hopper from unscrewing them.

Sizing Weigh Modules

To design a hopper scale that will weigh its contents accurately, you must use weigh modules with the proper load cell capacity. There are three main factors in sizing weigh modules for a hopper scale: (1) the weight of the empty hopper, (2) the weight of the hopper's contents when full, and (3) the number of weigh modules. The number of weigh modules will equal the number of supports that the hopper has.

A standard safety factor of 1.25 is normally figured into the calculation to compensate for uneven load distribution and any underestimation of weights. Certain installations have special environmental considerations requiring additional safety factors. Environmental considerations are discussed in Chapter 4.

Calculating Weigh Module Size

Suppose that you want to add weigh modules to a hopper designed to hold 20,000 pounds of grain. The hopper itself weighs 5,000 pounds and is supported by four threaded rods. Assume that only the standard safety factor is needed for this installation. To determine what size weigh modules you will need, calculate the total weight of the hopper and its contents, figure in any safety factors, and then divide by the number of weigh modules.

20,000 lb	Weight of grain
+ 5,000 lb	Weight of empty hopper
25,000 lb	Total weight
x 1.25	Safety factor
31,250 lb	Adjusted weight
÷ 4	Number of weigh modules
7,812.5 lb	Weight per weigh module

Since each weigh module will need to handle up to 7,812.5 pounds, the best choice for the job would be tension weigh modules with a capacity of 10,000 pounds each.

Installation

To maintain the system's weighing accuracy, make sure that the support steel will not deflect more than 1/16 inch under full working load.

General Procedure

1. Position the tension weigh modules around the tank so that each will support an equal portion of the tank's weight (see Figure 11-2). Make sure that the upper and lower support brackets line up with these positions.

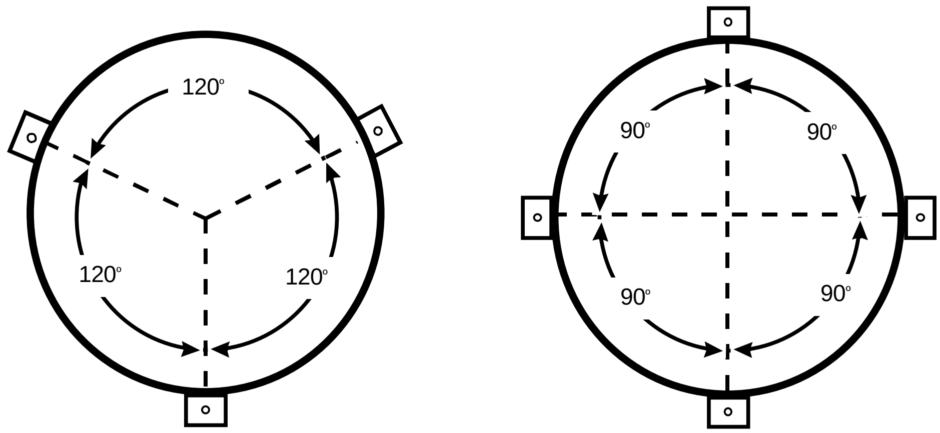


Figure 11-2: Plan View of Recommended Weigh Module Arrangements

2. Connect each weigh module clevis to an appropriately sized threaded rod with a jam nut on it. See Table 11-1 for clevis thread sizes. Tighten the jam nut against the clevis to prevent the threaded rod from turning.

0978 Weigh Module Capacity	Clevis Thread Size
50 to 300 lb	3/8 inch - 16 UNC
500 to 3,000 lb	3/4 inch - 10 UNC
5,000 to 10,000 lb	1 inch - 8 UNC
25 to 100 kg	M8 x 1.25
200 to 1,000 kg	M12 x 1.75
2,000 to 5,000 kg	M24 x 2

Table 11-1: Clevis Thread Sizes

⚠ WARNING

USE SAFETY CHAINS OR RODS TO PREVENT TANK FROM FALLING IN CASE OF COMPONENT FAILURE.

3. Place the threaded rod through a hole in the upper support bracket. Fit a backing plate and washer over the end of the threaded rod. Then double-nut the threaded rod against the backing plate. Attach the other end of the weigh module assembly in the same way (see Figure 11-3).

Note: Make sure that the upper and lower clevis brackets are turned at 90 degrees to each other. This will reduce swaying.

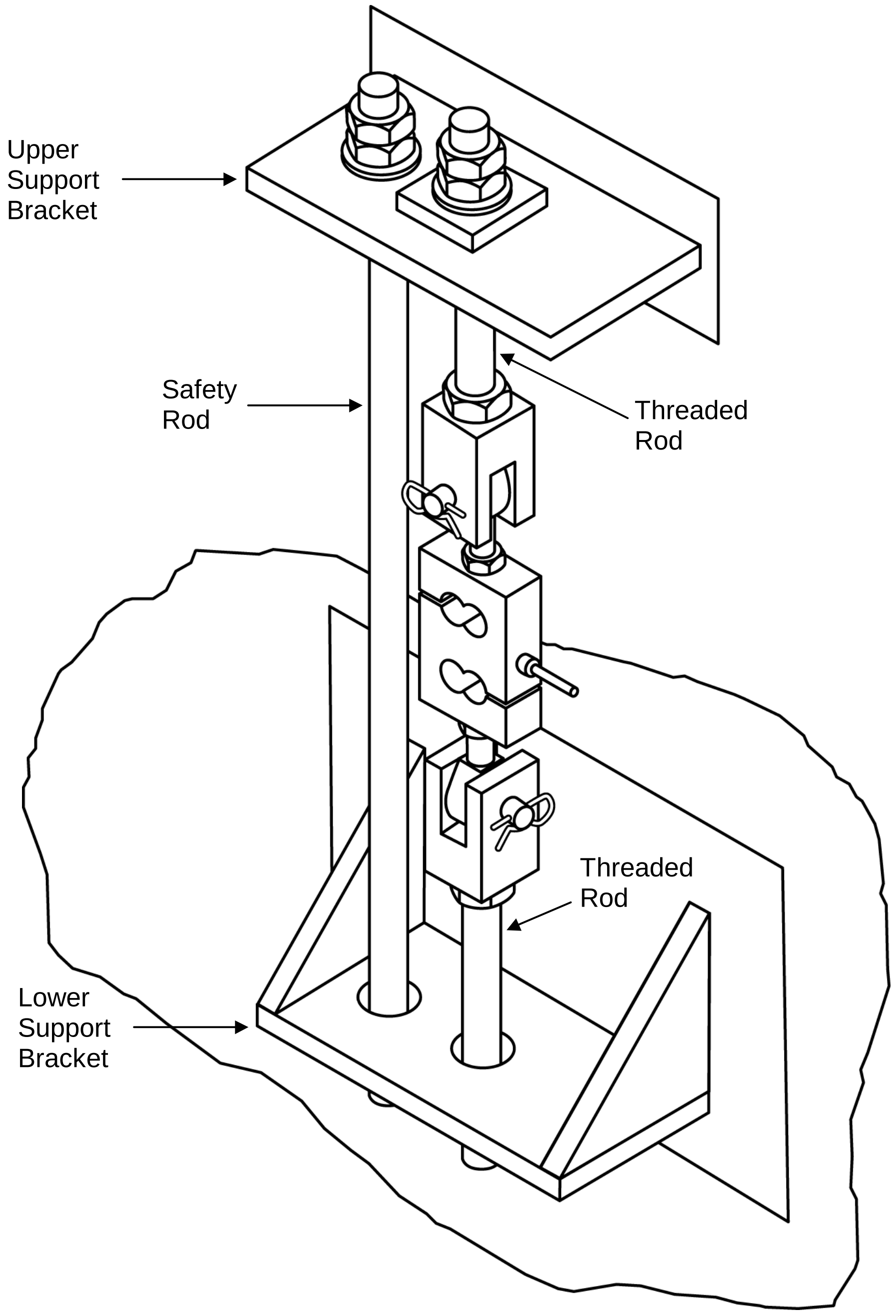


Figure 11-3: Typical Tension Weigh Module Installation

4. Install a safety rod next to each weigh module. Leave 1/8 inch clearance between the lower support bracket and the washer on the safety rod (see Figure 11-4).

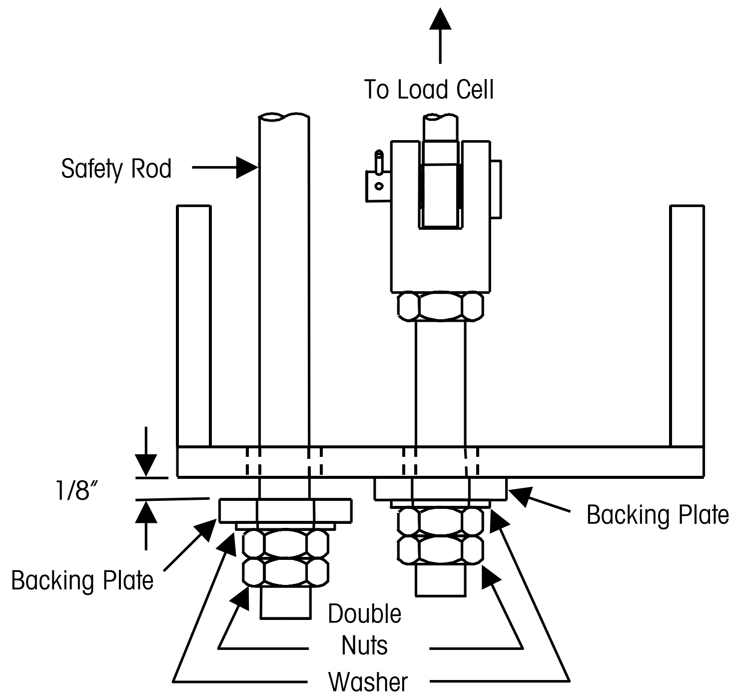


Figure 11-4: Weigh Module Assembly Attached to Lower Support Bracket

5. Once all weigh modules have been installed, make sure that each is hanging vertically (plumb).

6. Tack weld the backing plates into position. Pin or stake the nuts at both ends of the threaded rods to prevent them from turning.

7. If the suspended tank is subject to horizontal movement, install check rods to limit horizontal movement to less than 1/8 inch. Figures 11-5 and 11-6 show typical check rod arrangements. Figures 11-7, 11-8, and 11-9 show typical tension weigh module installations.

8. Mount the junction box in a location where the load cell cables can be properly terminated in the junction box. *Do not* mount the junction box on the scale.

Note: Each load cell is supplied with a standard length of cable. Do not lengthen or shorten load cell cables in the field! Changing the length of a load cell cable will affect the output signal from the load cell. If a cable is too long, simply coil the excess cable and place it in or near the junction box. Nonstandard lengths of cable can be ordered for applications that require them.

9. Connect the load cell cables to the junction box and terminate the wires according to the wiring and color code decal on the underside of the junction box lid.

10. Connect the junction box to the scale indicator with an appropriate cable.

11. Confirm that all live-to-dead connections are flexible and securely anchored at both the scale and the dead connection point.

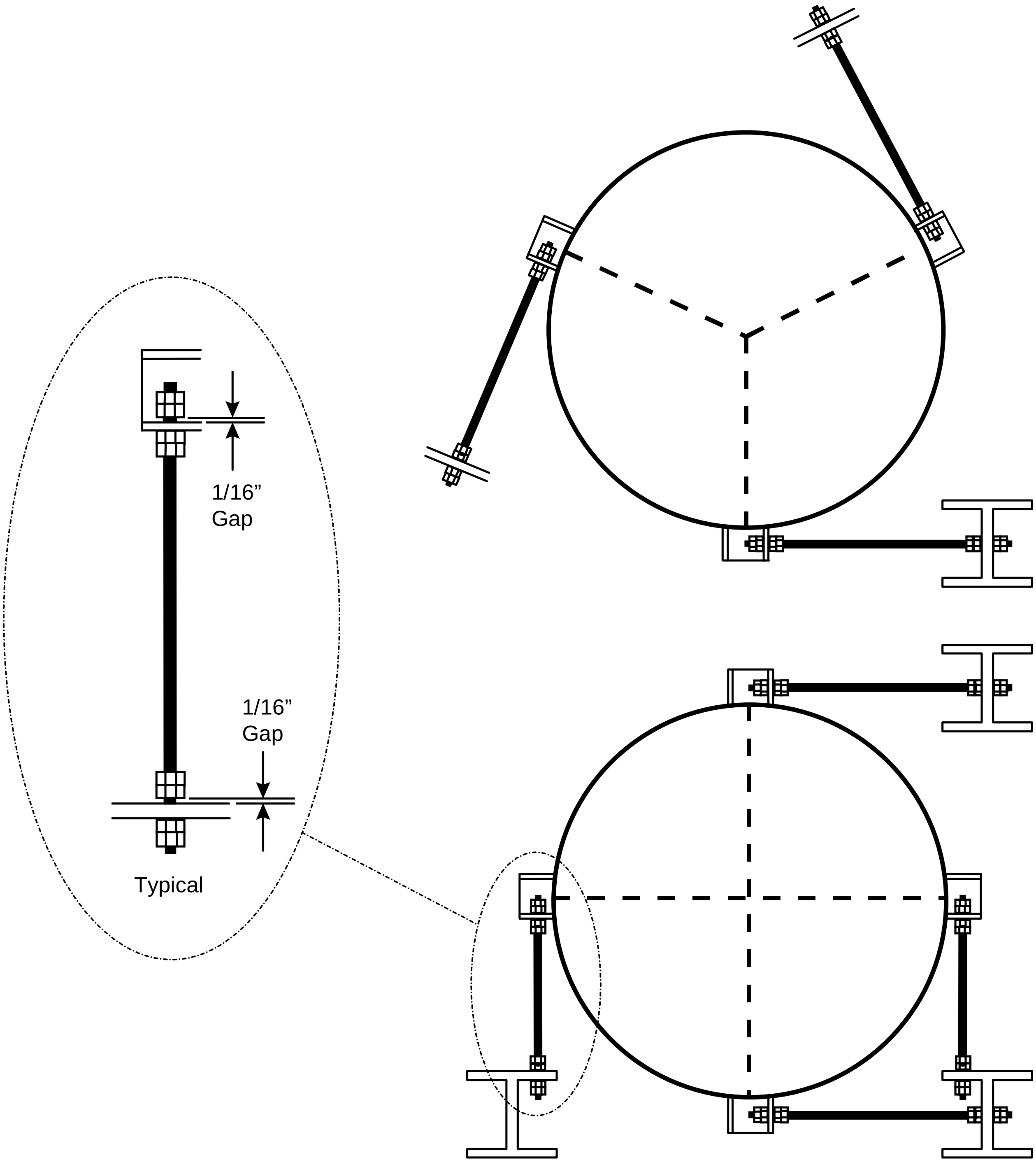


Figure 11-5: Plan View of Check Rods for Systems with Three and Four Weigh Modules

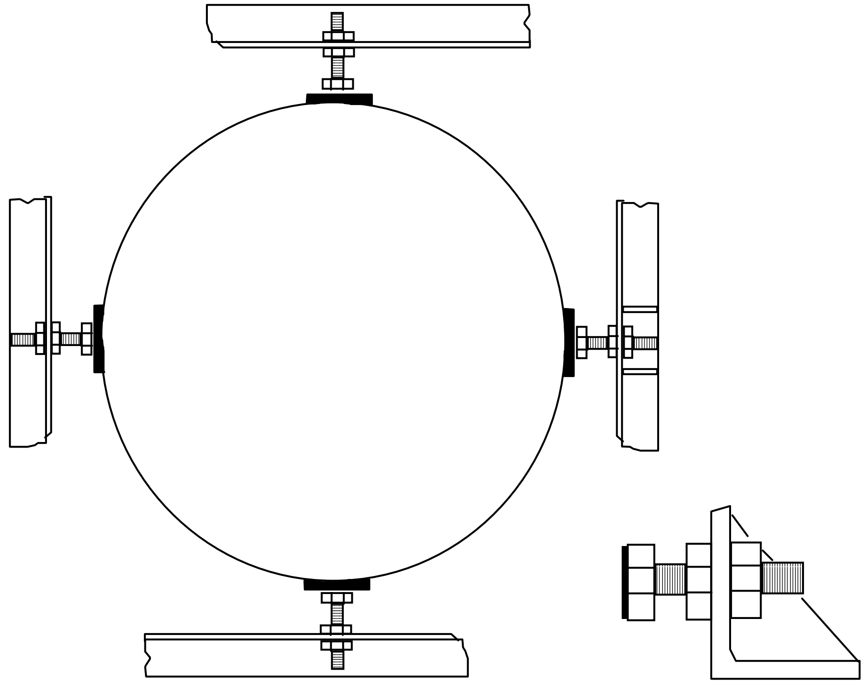


Figure 11-6: Plan View of Alternative Check Rod System

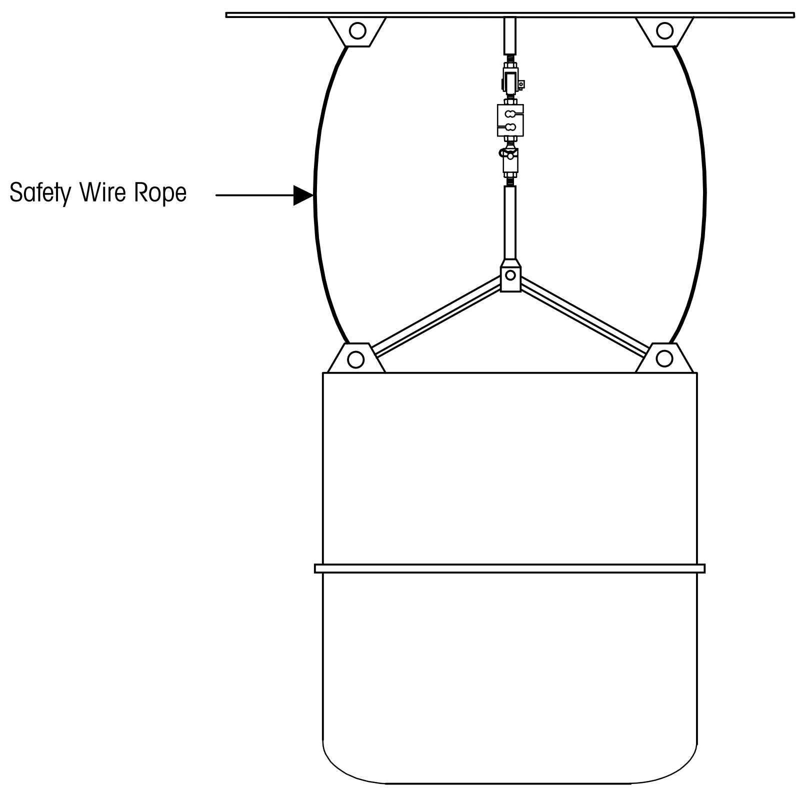


Figure 11-7: Sample Tension Weigh Module Installation

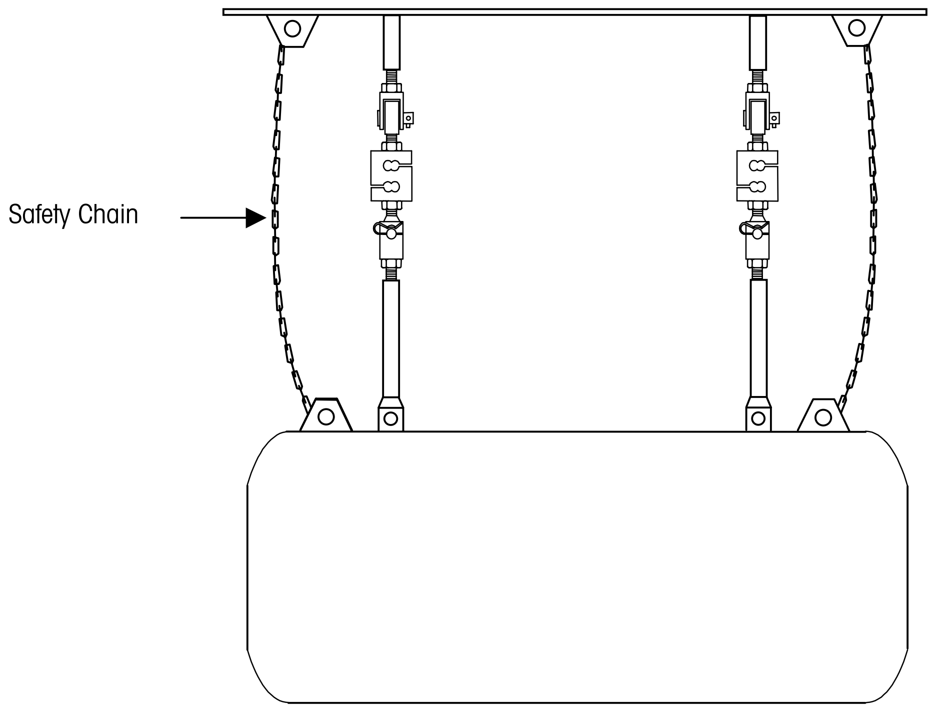


Figure 11-8: Sample Tension Weigh Module Installation

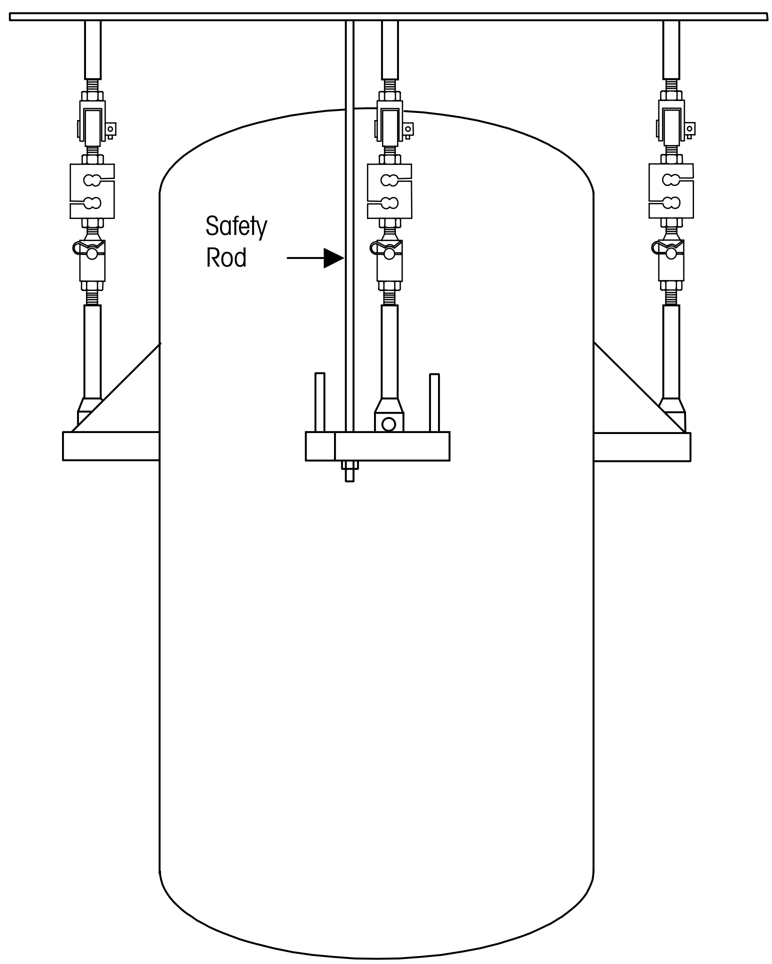
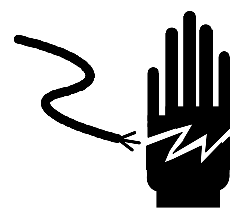


Figure 11-9: Sample Tension Weigh Module Installation

12 Calibration

When a weigh module system is installed, it must be calibrated so that the readings on the indicator accurately reflect the amount of weight placed on the scale. METTLER TOLEDO recommends calibrating a scale using test weights equal to the scale's full capacity. Specific instructions for calibration can be found in the technical manual for the digital indicator that will be used with the weigh modules.

The design or size of a tank scale might make it impossible to hang test weights equal to the scale's full capacity. For those applications, there are several other calibration options: calibration with test weights and material substitution, calibration with material transfer, and electronic calibration.



⚠ WARNING

PERMIT ONLY QUALIFIED PERSONNEL TO SERVICE THIS EQUIPMENT. EXERCISE CARE WHEN MAKING CHECKS, TESTS, AND ADJUSTMENTS THAT MUST BE MADE WITH POWER ON. FAILING TO OBSERVE THESE PRECAUTIONS CAN RESULT IN BODILY HARM.

Calibration with Test Weights

The most accurate, reliable way to calibrate a scale is with test weights. For this calibration procedure, a tank scale needs to be equipped with some type of mounting lugs for hanging test weights (see Figure 5-7).

1. Begin by taking a weight reading for the empty tank. Adjust the indicator so that it reads zero when the tank is empty.
2. Check each load cell to make sure it is working properly. Hang a test weight near one weigh module and take a reading. Move the test weight to a second weigh module and take a reading. Repeat for each weigh module to make sure that all load cells indicate the same weight.
3. Add test weights to the scale, taking a reading for each new weight that is added up to the full capacity of the scale. At the very least, you should take weight readings at one quarter of capacity, one half of capacity, three quarters of capacity, and full capacity.
4. If the tank scale will be used to weigh its contents as they are being discharged, you should also take weight readings as you remove the test weights.
5. Use the readings to plot a graph of the scale's performance from zero to full capacity (and from full capacity back to zero if those readings were taken).

Calibration with Test Weights and Material Substitution

For large tank scales, it is often physically impossible to hang test weights equal to the tank's full capacity. In those cases, you can use a combination of test weights and a material (such as water) to calibrate the scale.

1. For example, after taking a zero reading you might hang 500 lb of test weights and take a reading.
2. Then remove the test weights and add water to the tank until the weight reading is the same as that obtained with the test weights.
3. With the water still in the tank, hang the same test weights and take a second reading.
4. Continue substituting water for the test weights and taking readings until you reach the tank's full capacity.
5. Once you have taken readings from zero to full capacity, use them to plot a graph of the scale's performance.

Calibration with Material Transfer

When test weights cannot be used, you can calibrate a scale with material transfer. Instead of hanging test weights, weigh a material (such as water) on another scale and transfer it to the tank scale that is being calibrated. You can do this in a single transfer or in stages until you reach the tank's full capacity. This method yields only a rough indication of the scale's performance. It depends on the accuracy of the existing scale and the integrity of the transfer process. Even in the best conditions, you will not know if allowable errors are cumulative or compensating.

Electronic Calibration

When using the electronic calibration method, replace the load cell cables with leads from a load cell simulator. The simulator sends out a signal equal to the signal the load cells should produce. Electronic calibration is noted for its speed and simplicity; however, it calibrates only the electronics. Because it assumes that the tank and all mechanical connections are working properly, electronic calibration does not verify the scale's performance.

1. With the simulator adjusted to zero output, set the indicator to zero.
2. Adjust the simulator to full output (a signal equal to that which all the load cells should produce at their rated capacity).
3. Adjust the indicator to show the total capacity of all load cells in the system.
4. Attach the load cell input to the indicator.
5. Set the indicator to read zero for the empty weight of the tank.

13 Indicators and Applications

Indicators

The basic job of a scale indicator is to receive the signal transmitted by the load cells and display it as a weight reading. For process weighing applications, indicators must provide fast, repeatable weight readings that remain stable at relatively high resolutions. But in many cases, the key factor in selecting an indicator is its ability to communicate with the process control equipment used for a specific application.

Communications

What type of communications capabilities an indicator needs depends on how you plan to use the weight data provided by the scale. For a very simple process, an indicator might use setpoints to tell an operator when to manually fill or empty a tank. For an automated process, the setpoints could actually control valves or feeders. For more complex systems, an indicator might need to interact with a programmable logic controller (PLC) that runs an entire processing operation.

An indicator’s ability to interact with other equipment is determined by its communication inputs and outputs. The types of inputs and outputs are described below:

Discrete Input/Output

Discrete inputs are connections used to send commands from an indicator to a scale. Typical commands are Clear, Tare, Print, Zero, switch weight units, switch scales, and disable weight display.

Discrete outputs are connections used to relay on/off information from the scale. They do not transmit actual weight values. Discrete outputs can be used for setpoints or scale status information such as scale in motion, zero, under zero, over capacity, and net/gross weighing mode. Because they are a direct connection from the scale to the indicator, these outputs operate very quickly.

BCD Output

Binary Coded Decimal (BCD) outputs transmit weight values in a binary code format that can be used by a PLC or other device. For each digit of a weight value, the indicator sends a coded 8,4,2, and 1 output. Cabling normally limits the location of the indicator to within 10 to 15 feet of a PLC.

Analog Output

Analog output is the variable signal of DC voltage that represents a weight value, which can be used by a PLC located up to 50 feet from the indicator. The weight data is converted several times during its transmission from load cells to PLC, with the signal losing a percentage of its accuracy for each conversion.

Serial Communication Output

Serial communication ports are used to send weight data from the scale to a remote display, fill valves, computer, PLC, printer, or other equipment. These outputs can transmit information about scale status, scale capacity, increment size, setpoint status, weight unit, and net/gross weighing mode. Serial outputs can transmit more information than discrete outputs but have a slower update rate. Long cabling distances are possible, but connection with a PLC requires additional hardware/software.

These outputs can communicate in demand, continuous, or host mode. Demand mode sends weight data to a printer or other device only when requested. Continuous mode transmits weight data repeatedly to a remote display or other device. Host mode allows two-way communication between the scale and a host computer.

Direct PLC Interface

A direct PLC interface makes it possible to transmit the following types of information:

- Weight Data: gross, tare, net, rate.
- Status Data: motion, net mode, setpoints, data integrity.
- Commands: tare, clear, print, zero, load setpoint, load tare, control display messages.
- Floating Point Data: special format with additional data and commands.

It requires a special printed circuit board (PCB) to interface with a specific manufacturer's PLC. The following options are available for METTLER TOLEDO Jaguar and Panther indicators:

- **Allen-Bradley™ RIO** – This PCB enables an indicator to operate as an Allen-Bradley remote input/output (RIO) device. It allows discrete transfer of data from the indicator to the PLC and block transfer of data between the PLC and other devices.
- **Profibus™-DP** – This PCB enables an indicator to communicate with a Siemens or Texas Instruments PLC. Discrete data can be input or output in large blocks.
- **Modbus Plus™** – This PCB enables an indicator to communicate with a Modicon PLC. Discrete data can be input or output in large blocks.

Weighing Accuracy

Dynamic Weighing

Vibration or motion on a scale can make it difficult to get an accurate weight reading. For dynamic weighing applications where the load on a scale is constantly in motion, indicators need to be able to take a series of weight readings and use those readings to calculate an average weight.

Filtering

Environmental noise is vibration caused by nearby machinery, unstable structures, or wind and air currents. Instead of calculating an average weight reading, most indicators can filter out this noise. An indicator with a wide range of filtering levels usually can provide the best combination of noise reduction and update speed.

Jaguar Indicator

The Jaguar indicator is designed for use with complex automated processing systems. It offers the greatest range of options for interacting with process equipment.

- Direct PLC Interface for Allen-Bradley RIO, Profibus-DP, or Modbus Plus.

  Up to four Jaguar indicators can share one PCB.

  Block transfer of floating point and shared data.

  Indicator can display messages from PLC.
- Discrete I/O: Four standard inputs and four standard outputs.

  Option for 12 inputs and 12 outputs.

  12 super setpoints with preact, dribble, and tolerance values.
- BCD Output: Optional 9323 BCD module.
- Analog Output: Optional analog kit with two separate outputs.
- Serial I/O: Two standard serial ports (RS-232/20 mA CL and RS-232/RS-422/RS-485) and two optional serial ports(RS-232 and RS-232/RS-422/RS-485).
- Filtering: TraxDSP with a very large selection of filtering levels.
- Internal Resolution: 2,000,000 increments.
- Load Cells: Supports up to sixteen 350Ω load cells.
- Enclosures: General purpose, panel mount, and harsh environment.

Lynx Indicator

The Lynx indicator is a reliable scale terminal with strong capabilities for interacting with process equipment.

- Discrete I/O: Three inputs and five outputs.

  Five one-speed setpoints, two two-speed setpoints, or combination.
- BCD Output: Optional BCD kit.
- Analog Output: Optional analog kit.
- Serial I/O: Three bidirectional serial ports (RS-232/RS-485, RS-232/20 mA CL, and RS-422).
- Filtering: TraxDSP with a large selection of filtering levels.
- Internal Resolution: 2,000,000 increments.
- Load Cells: Supports up to eight 350Ω load cells.
- Enclosures: Panel mount and harsh environment.

LynxBatch Indicator

The LynxBatch indicator has the same basic features as the Lynx indicator, plus a wide range of capabilities for controlling batching processes.

Panther Indicator

The Panther indicator is a reliable scale terminal with basic capabilities for interacting with processing equipment.

- Direct PLC Interface for Allen-Bradley RIO, Profibus-DP, or Modbus Plus.

  Each Panther indicator needs its own PCB.
- Discrete I/O: One inputs and three outputs.

  Two one-speed setpoints.
- BCD Output: Optional 9323 BCD module.
- Analog Output: Optional analog kit.
- Serial I/O: One bidirectional serial port (RS-232).
- Filtering: TraxDSP with basic selection of filtering levels.
- Internal Resolution: 1,000,000 increments.
- Load Cells: Supports up to eight 350Ω load cells.
- Enclosures: Panel mount and harsh environment.

Puma Indicator

The Puma indicator is an intrinsically safe scale terminal for use in hazardous environments. It uses fiber optic cables to communicate with peripheral equipment.

- Two optional fiber optic serial communication ports (RS-232/20 mA CL): BCD output, analog output, and Host PC/PLC/DCS systems interface.
- Setpoints: When used with a 3015 Setpoint Controller, the Puma indicator can provide four one-speed cutoffs and two two-speed cutoffs.
- Filtering: Selectable from 0.25 to 2.4 seconds.
- Internal Resolution: 1,000,000 increments.
- Load Cells: Supports up to four 350Ω load cells.
- Enclosure: Harsh environment.

Applications

Figure 13-1 shows a typical weigh module system with the indicator connected to a customer's PLC.

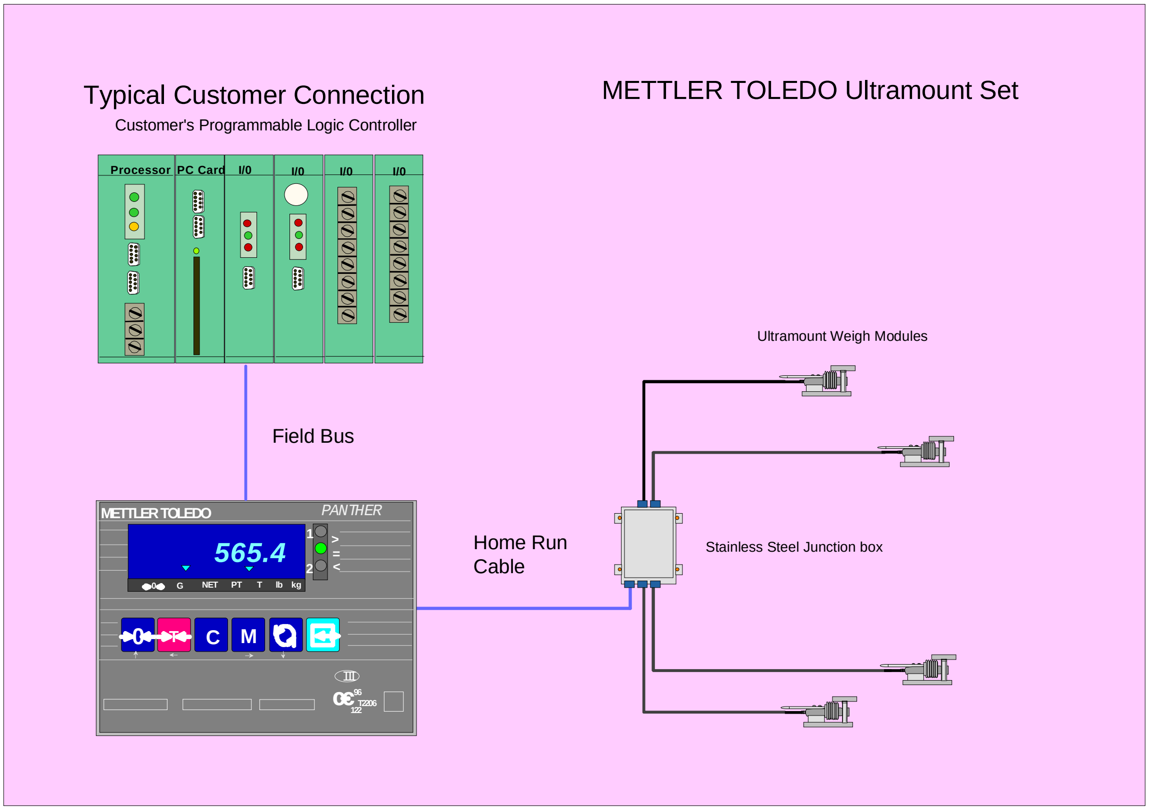


Figure 13-1: Typical Weigh Module System

Figure 13-2 shows a weigh module system for a hazardous environment. The weigh module system is located within a hazardous area barrier and connected to an indicator and PLC in a safe area.

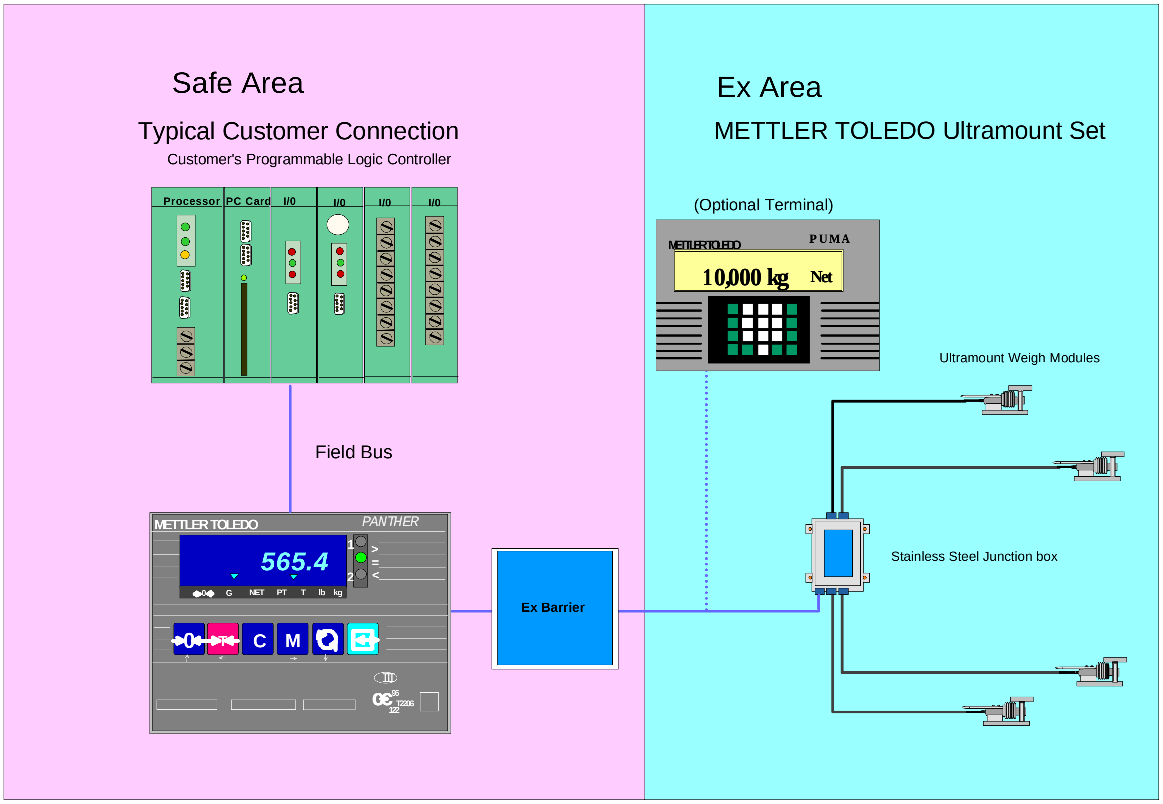


Figure 13-2: Weigh Module System for a Hazardous Environment

Figure 13-3 shows an overview of sample weigh module systems.

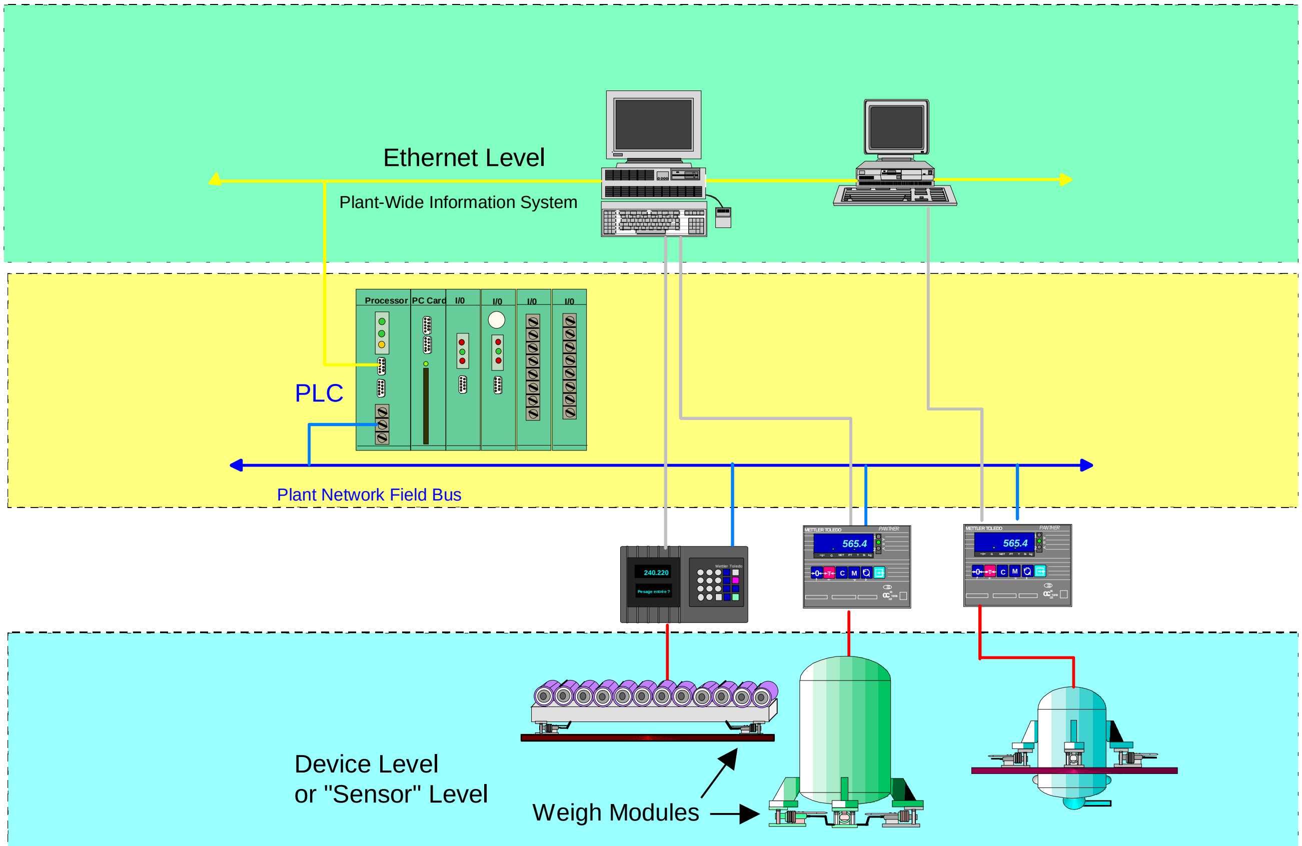


Figure 13-3: Overview of Weigh Module Systems

14 Appendices

Appendix 1: Certificates of Conformance

Tables 14-1, 14-2, and 14-3 list certificate of conformance numbers for load cells used in METTLER TOLEDO weigh modules.

Certificate of Conformance	Load Cell Model	Accuracy Class	n_{max}	Capacity
97-072	713	III	3,000 (Single Cell) 5,000 (Multiple Cell)	500-10,000 lb
91-090	736	III	3,000 (Multiple Cell)	50-5,000 lb
91-090	736	III L	10,000 (Multiple Cell)	50-5,000 lb
88-008A4	743	III	5,000 (Multiple Cell)	20,000-45,000 lb
88-008A4	743	III L	10,000 (Multiple Cell)	75,000 lb
92-108A2	745 & 745A	III	3,000 (Single Cell) 5,000 (Multiple Cell)	500-20,000 lb
99-021	777	III	3,000 (Single Cell) 5,000 (Multiple Cell)	10-1,000 kg
99-093	790	III L	10,000 (Multiple Cell)	20,000-200,000 lb

Table 14-1: NIST Certificates of Conformance

Test Certificates	Load Cell Model	Accuracy Class	Number of Approved Increments	Capacity
TC2826	736	C	3,000 (Single Cell)	50-5,000 kg
TC2977	743	C	2,000 (Single Cell)	9,072-20,412 kg
TC2154	744 & 745	C	3,000 (Single Cell)	220-4,400 kg

Table 14-2: European Test Certificates

Certificate Number	Load Cell Model	Accuracy Class	Number of Approved Increments	Capacity
R60/1991-NL-96.08	725	C	3,000 (Single Cell)	50-5,000 kg
R60/1991-NL-97.31	743	C	2,000 (Single Cell)	9,072-20,412 kg
R60/1991-NL-99.01	745A	C	3,000 (Single Cell)	220-4,400 kg

Table 14-3: OIML Certificates of Conformance

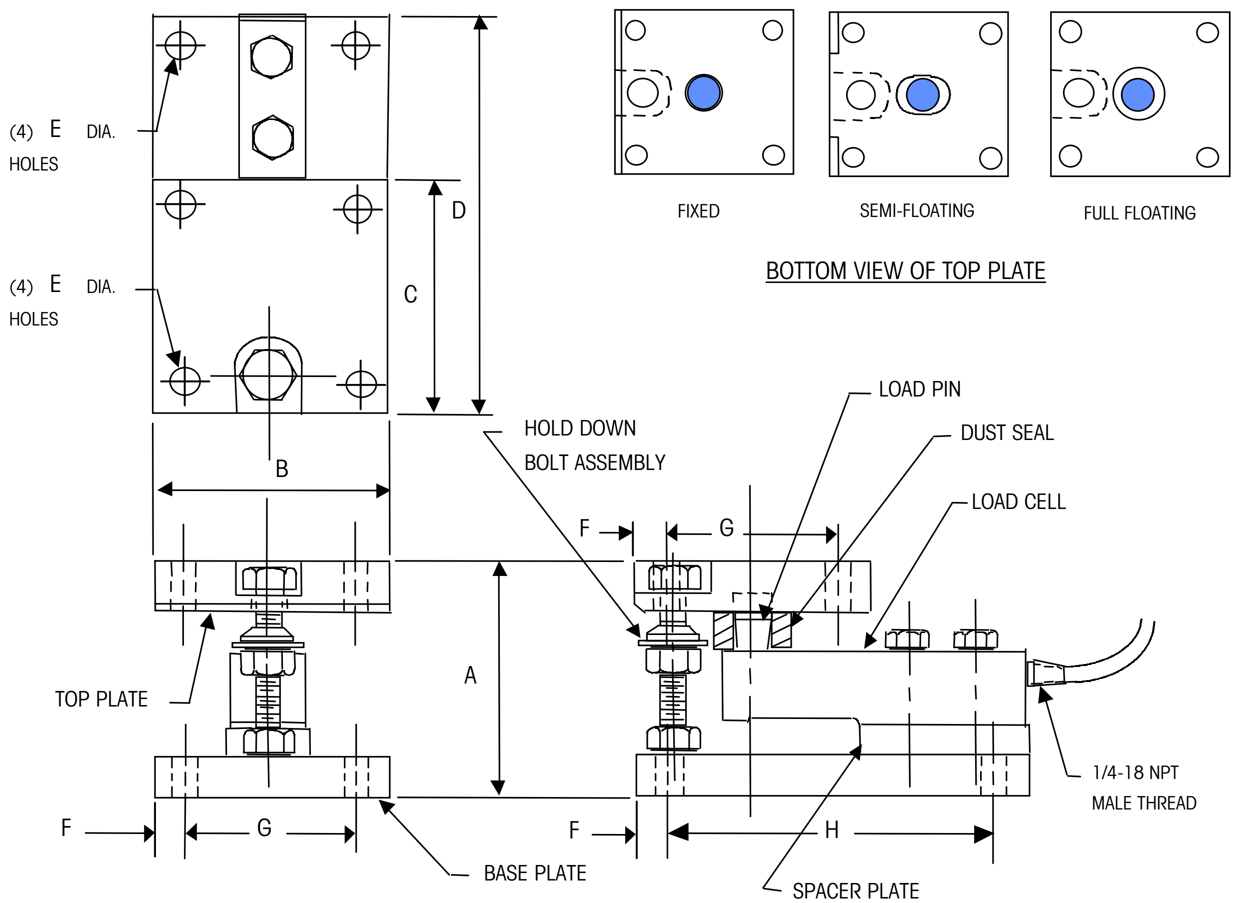
Note: The value defined as n_{max} is the maximum number of scale divisions for which a load cell complies with the applicable requirements.

Appendix 2: Design Qualification Form

METTLER TOLEDO WEIGH MODULE DESIGN QUALIFICATION FORM

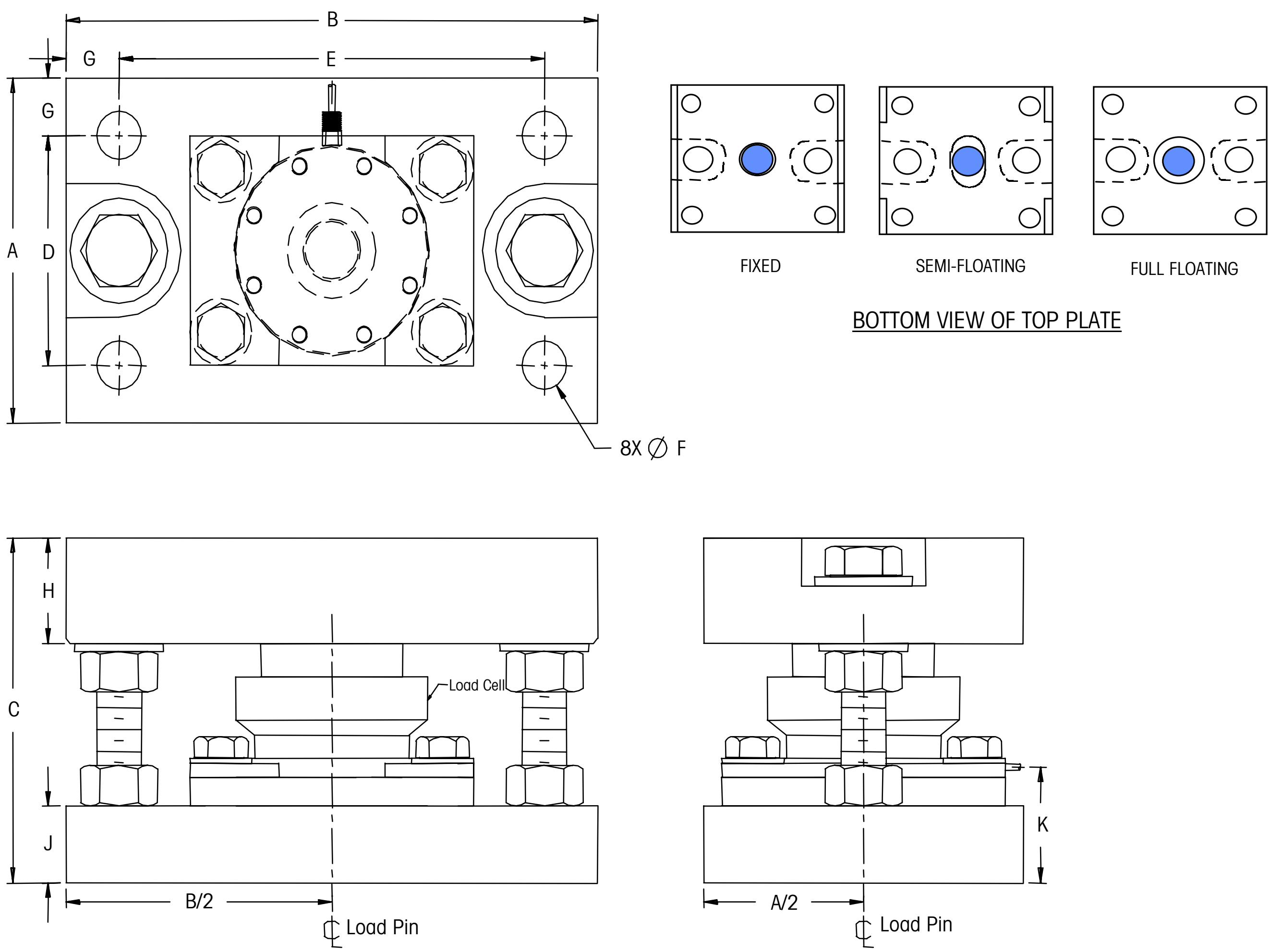
1. Type: Tank ____________ Hopper ____________ Vessel ____________ Other ____________	
2. Dimensions: Length ____________ Width (dia.) ____________ Height ____________	
3. Number of supports (Legs / Lugs / Suspension Rods):	
4. Distance between supports:	
5. Dimension of Legs / Rods: Length ____________ Width (dia.) ____________ Height _____________	
6. Gross capacity:	7. Empty Weight:
8. Nominal load cell capacity (#6 ÷ #3 × 1.25 Safety Factor):	
9. Required system resolution (increment size):	
10. Seismic conditions? Yes ______ No ______	11. If yes, UBC seismic zone:
12. Is system located outdoors? Yes ______ No ______	13. If yes, design wind speed in MPH:
14. Is the tank or vessel jacketed? Yes ______ No ______	
15. Jacket will contain: Coolant ______ Type ____________ Heat source ______ Type ____________	
16. Does jacket continuously circulate? Yes ______ No ______	
17. Is there an agitator? Yes ______ No ______	
18. Will agitator be required to cycle when taking weight readings? Yes ______ No ______	
19. What is the ambient temperature for the area of operation? Min. ____________ Max. ____________	
20. If a reactor vessel, what are the internal temperatures? Min. ____________ Max. ____________	
21. Number of piping terminations (inlets/outlets) to the vessel:	
22. How many are: Horizontal to vessel ____________ Vertical to vessel _____________	
23. Is the vessel vented? Yes ______ No ______	
24. Is the area of operation Hazardous/Classified? Yes ______ No ______	
25. If yes, state: Class ____________ Division _____________ Group ____________	
26. Autoignition temperature of the product to be weighed:	
27. Load cells to be mounted on: Concrete floor ______ I-Beam ______ Mezzanine ______	
28. Length of cable required from vessel to indicator (Home Run Cable): ____________	
29. Provisions on the tank, vessel, or hopper to hang calibration weights? Yes ______ No ______	
Prepared By Date	Approved By Date

Appendix 3: Weigh Module Dimensions



Cell Capacity	A	B	C	D	E Diameter	F	G	H
250 - 5K lb	4.12 in.	4.50 in.	4.50 in.	7.00 in.	0.44 in.	0.50 in.	3.50 in.	6.00 in.
10K lb	5.38 in.	6.00 in.	6.00 in.	9.25 in.	0.69 in.	1.00 in.	4.00 in.	7.25 in.
20K - 30K lb	7.50 in.	8.00 in.	8.00 in.	14.00 in.	0.81 in.	1.00 in.	6.00 in.	12.00 in.
45K lb	9.00 in.	9.00 in.	9.00 in.	16.00 in.	1.12 in.	1.25 in.	6.50 in.	13.50 in.
220 - 2,200 kg	104.8 mm	114.3 mm	114.3 mm	177.8 mm	11.1 mm	12.7 mm	88.9 mm	152.4 mm
4,400 kg	136.5 mm	152.4 mm	152.4 mm	235.0 mm	17.5 mm	25.4 mm	101.6 mm	184.2 mm
9,072 - 13,608 kg	190.5 mm	203.2 mm	203.2 mm	355.6 mm	20.6 mm	25.4 mm	152.4 mm	304.8 mm
20,412 kg	228.6 mm	228.6 mm	228.6 mm	406.4 mm	28.4 mm	31.7 mm	165.1 mm	342.9 mm

Figure 14-1: Model 0958 Flexmount Weigh Module Dimensions

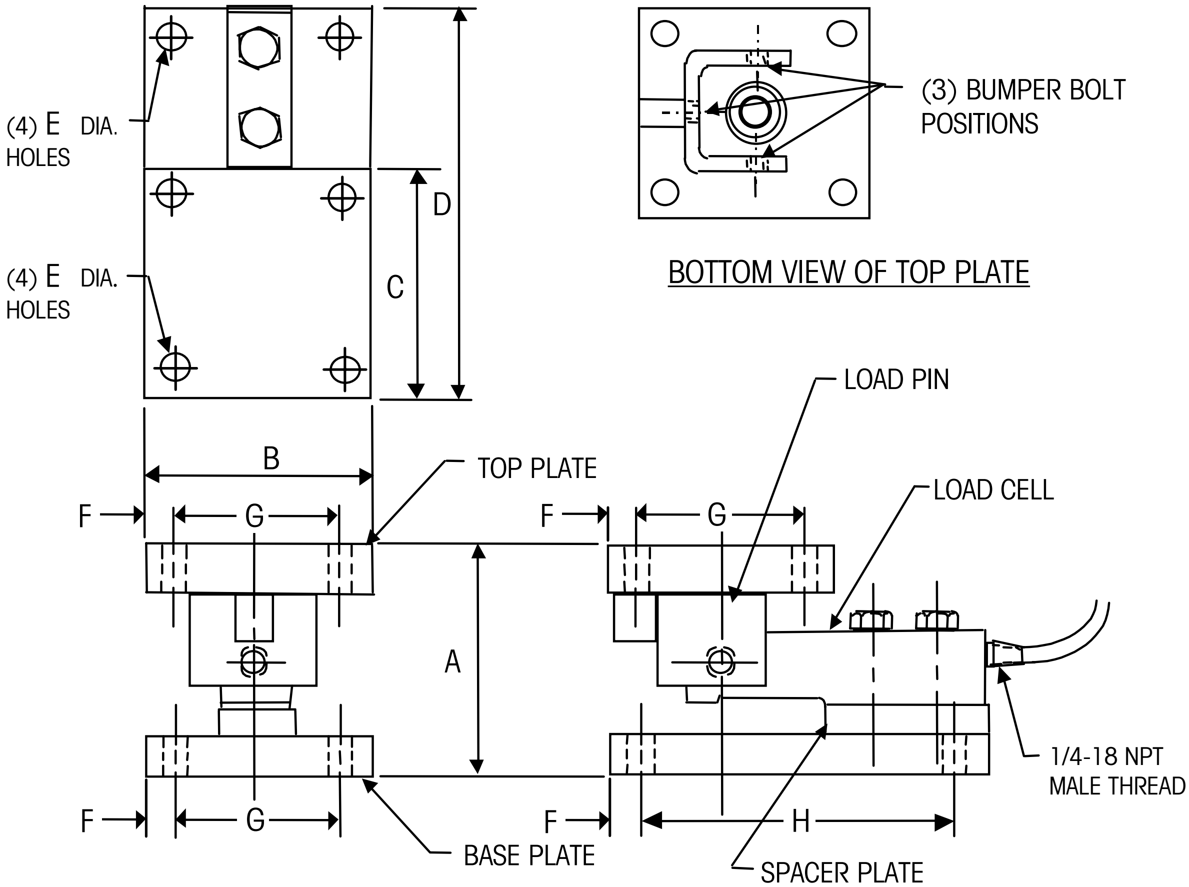


Cell Capacity	A	B	C*	D	E	F Diameter
50K, 75K, 100K lb	9 inches 229 mm	15 inches 381 mm	9 inches 229 mm	6 inches 152 mm	12 inches 305 mm	1.25 inches 31.8 mm
150K, 200K lb	12 inches 305 mm	18 inches 457 mm	10 inches 254 mm	8 inches 203 mm	14 inches 356 mm	1.625 inches 41.3 mm

Cell Capacity	G	H	J	K
50K, 75K, 100K lb	1.5 inches 38.1 mm	2.75 inches 69.9 mm	2 inches 50.8 mm	3 inches 76.2 mm
150K, 200K lb	2 inches 50.8 mm	2.75 inches 69.9 mm	2 inches 50.8 mm	3.25 inches 82.6 mm

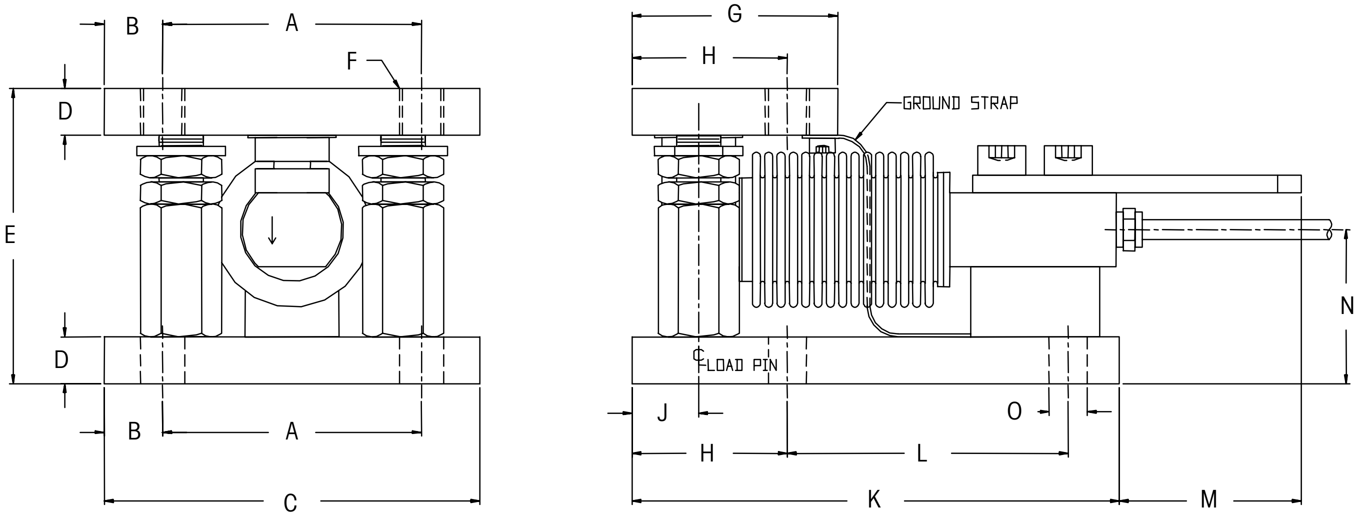
*Dimension shown is for weighing position. Add 1/8 inch for shipping/installation height.

Figure 14-2: Model 0958 Flexmount HD Weigh Module Dimensions



Cell Capacity	A	B	C	D	E Dia.	F	G	H
250 - 5K lb	4.12 in.	4.50 in.	4.50 in.	7.00 in.	0.44 in.	0.50 in.	3.50 in.	6.00 in.
10K lb	5.38 in.	6.00 in.	6.00 in.	9.25 in.	0.69 in.	1.00 in.	4.00 in.	7.25 in.
20K - 30K lb	7.50 in.	8.00 in.	8.00 in.	14.00 in.	0.81 in.	1.00 in.	6.00 in.	12.00 in.
45K lb	9.00 in.	9.00 in.	9.00 in.	16.00 in.	1.12 in.	1.25 in.	6.50 in.	13.50 in.
220 - 2,200 kg	104.8 mm	114.3 mm	114.3 mm	177.8 mm	11.1 mm	12.7 mm	88.9 mm	152.4 mm
4,400 kg	136.5 mm	152.4 mm	152.4 mm	235.0 mm	17.5 mm	25.4 mm	101.6 mm	184.2 mm
9,072 - 13,608 kg	190.5 mm	203.2 mm	203.2 mm	355.6 mm	20.6 mm	25.4 mm	152.4 mm	304.8 mm
20,412 kg	228.6 mm	228.6 mm	228.6 mm	406.4 mm	28.4 mm	31.7 mm	165.1 mm	342.9 mm

Figure 14-3: Model 0958 Centerlign Weigh Module Dimensions

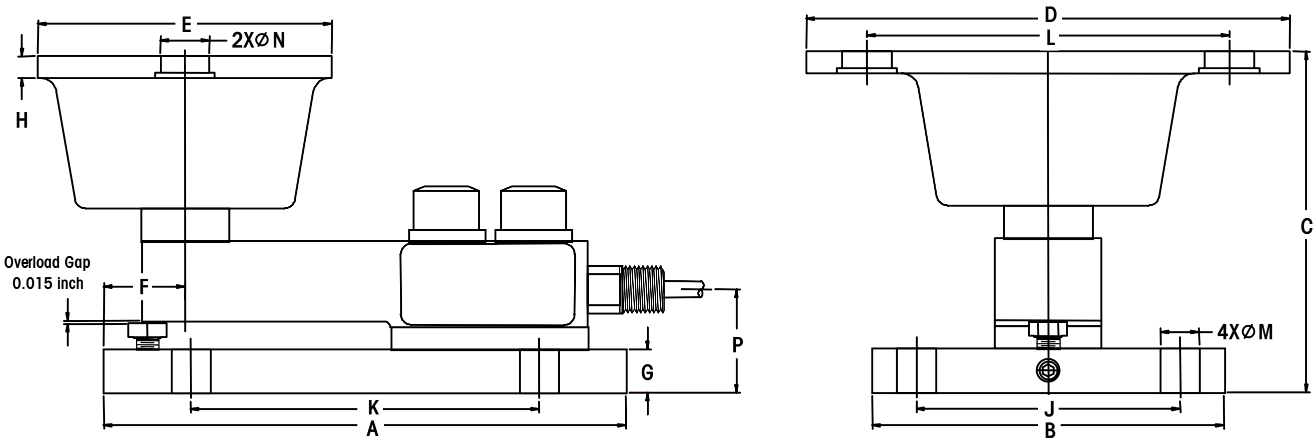


A	B	C	D	E*	F Thread	G
2.76 inches	0.62 inch	4.00 inches	0.50 inch	3.15 inches	--	2.19 inches
70 mm	16 mm	102 mm	13 mm	80 mm	M12 x 1.75	56 mm

H	J	K	L	M	N	O Dia.
1.65 inches	0.71 inch	5.19 inches	2.99 inches	1.94 inches	1.64 inches	0.41 inch
42 mm	18 mm	132 mm	76 mm	49 mm	42 mm	10 mm

*Dimension shown is in weighing configuration. Shipping height is 3.23 inches (82 mm) with top plate in raised position.

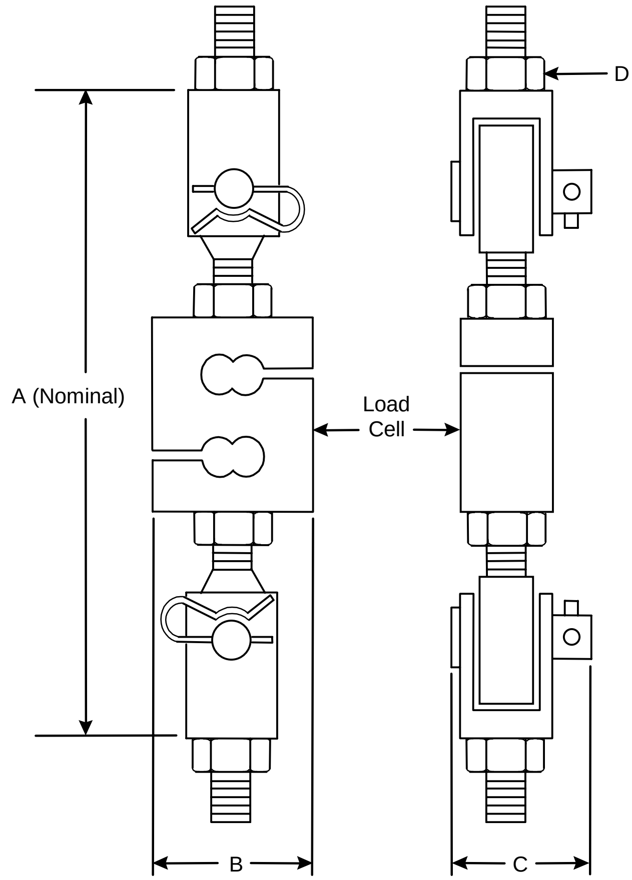
Figure 14-4: Model 0972 Ultramount Weigh Module Dimensions



Cell Capacity	A	B	C	D	E	F	G
250 lb	6.00 inches (152.4 mm)	4.00 inches (101.6 mm)	3.12 inches (79.2 mm)	3.88 inches (98.6 mm)	2.38 inches (60.5 mm)	0.93 inch (23.6 mm)	0.50 inch (12.7 mm)
500 lb	6.00 inches (152.4 mm)	4.00 inches (101.6 mm)	3.88 inches (98.6 mm)	5.50 inches (139.7 mm)	3.38 inches (85.9 mm)	0.93 inch (23.6 mm)	0.50 inch (12.7 mm)
1,000 lb	6.00 inches (152.4 mm)	4.00 inches (101.6 mm)	4.00 inches (101.6 mm)	5.12 inches (130 mm)	3.00 inches (76.2 mm)	0.93 inch (23.6 mm)	0.50 inch (12.7 mm)
2,000 lb, 2,500 lb	6.00 inches (152.4 mm)	4.00 inches (101.6 mm)	4.00 inches (101.6 mm)	6.25 inches (158.8 mm)	4.62 inches (117.3 mm)	0.93 inch (23.6 mm)	0.50 inch (12.7 mm)

Cell Capacity	H	J	K	L	M Diameter	N Diameter	P
250 lb	0.22 inch (5.6 mm)	3.00 inches (76.2 mm)	4.00 inches (101.6 mm)	3.00 inches (76.2 mm)	0.44 inch (11.2 mm)	0.34 inch (8.6 mm)	1.19 inches (30.2 mm)
500 lb	0.25 inch (6.4 mm)	3.00 inches (76.2 mm)	4.00 inches (101.6 mm)	4.12 inches (104.6 mm)	0.44 inch (11.2 mm)	0.56 inch (14.2 mm)	1.19 inches (30.2 mm)
1,000 lb	0.25 inch (6.4 mm)	3.00 inches (76.2 mm)	4.00 inches (101.6 mm)	4.12 inches (104.6 mm)	0.44 inch (11.2 mm)	0.44 inch (11.2 mm)	1.38 inches (35.1 mm)
2,000 lb, 2,500 lb	0.38 inch (9.7 mm)	3.00 inches (76.2 mm)	4.00 inches (101.6 mm)	5.06 inches (128.6 mm)	0.44 inch (11.2 mm)	0.56 inch (14.2 mm)	1.38 inches (35.1 mm)

Figure 14-5: Model VLM2 Value Line Weigh Module Dimensions



Cell Capacity	A	B	C	D
50 - 300 lb	7 5/8 inches	2 inches	1 3/8 inches	3/8-16 UNC
500 - 3,000 lb	10 9/16 inches	2 1/4 inches	1 7/8 inches	3/4-10 UNC
5,000 lb	12 5/8 inches	2 3/4 inches	2 3/4 inches	1-8 UNC
10,000 lb	12 5/8 inches	3 inches	2 3/4 inches	1-8 UNC
25 - 100 kg	180 mm	50.8 mm	32 mm	M8 x 1.25
200 - 1,000 kg	250 mm	57.2 mm	49 mm	M12 x 1.75
2,000 kg	450 mm	69.9 mm	83 mm	M24 x 2
5,000 kg	450 mm	76.2 mm	83 mm	M24 x 2

Figure 14-6: Model 0978 Tension Weigh Module Dimensions

Appendix 4: Calculating Reaction Forces

The effect of wind or seismic events on a tank is defined in terms of reaction forces (downward, upward, and shear). For the sample application used in this appendix, we will assume that the total horizontal shear equals the equivalent force applied at the tank's center of gravity (c.g.). This total shear force will be distributed evenly among the weigh module supports. Methods for determining wind and seismic forces at a tank's center of gravity are discussed in Chapter 4.

⚠ CAUTION

THE FOLLOWING CALCULATIONS ARE PROVIDED AS GUIDELINES ONLY. THEY SHOULD NOT REPLACE A STRUCTURAL ENGINEERING EVALUATION OF THE APPLICATION BY A REGISTERED PROFESSIONAL ENGINEER WHO IS FAMILIAR WITH LOCAL BUILDING CODES.

Vertical reaction forces are calculated using statics, which is the study of bodies at rest (equilibrium). The following factors are used to calculate reaction forces for a tank scale:

h_T = Height of Tank (feet)

h_L = Height of Tank's Legs (feet)

d = Diameter of Tank (feet)

W_T = Weight of Empty Tank (pounds)

W_G = Weight of Full Tank (pounds)

$R_{1,2}$ = Reaction Forces at Weigh Module

R_T = Reaction Force at Weigh Module due to Empty Tank Weight

R_G = Reaction Force at Weigh Module due to Full Tank Weight

F = Equivalent Force due to Wind or Seismic Event (applied at tank c.g.)

F_D = Downward Force on Weigh Module

F_U = Upward Force on Weigh Module

F_Y = Vertical Force on Weigh Module

M_A = Moment about Point A

Circular Tank with Four Weigh Modules

The following sample shows how statics is used to calculate reaction forces for an outdoor installation of a circular tank with four weigh modules.

Note: F is a horizontal force applied at the tank's center of gravity. It is usually denoted F_W for wind force and F_{EQ} or V for seismic force.

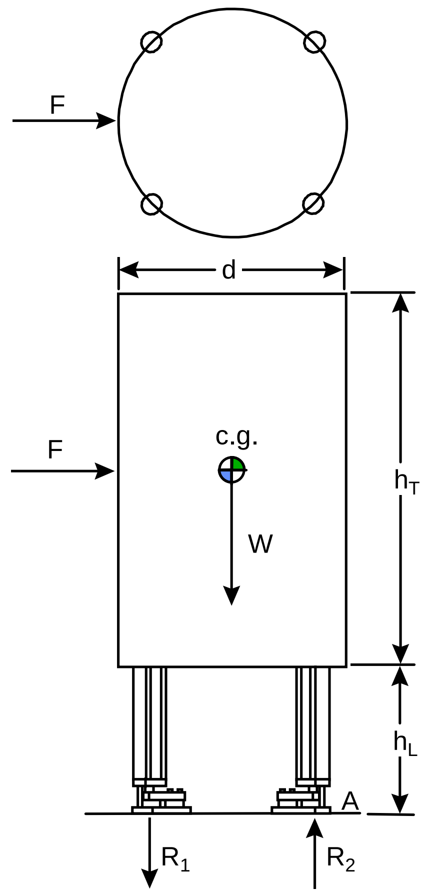


Figure 14-7: Circular Tank with Four Weigh Modules

Moment about point *A* due to *F* (horizontal force at tank's center of gravity)

$$= - F [h_L + 0.5\, h_T]$$

Moment about point *A* due to reaction force R_1

$$= 2\, R_1\, d \sin 45\,°$$

If a tank is at equilibrium, the sum of the moments about point *A* will equal zero:

$$\Sigma M_A = 0$$

Solve for R_1

$$F [h_L + 0.5\, h_T] = 2\, R_1\, d \sin 45\,°$$

$$R_1 = \frac{F}{1.414\, d} [h_L + 0.5\, h_T]$$

Full Tank, Solve for R_G

$$\Sigma F_Y = 0$$

$$2R_1 + 2R_2 = W_G$$

assuming equal load distribution

$$R_1 = R_2 = R_G$$

$$R_G = \frac{W_G}{4}$$

Empty Tank, Solve for R_T

$$\Sigma F_Y = 0$$

$$2R_1 + 2R_2 = W_T$$

assuming equal load distribution

$$R_1 = R_2 = R_T$$

$$R_T = \frac{W_T}{4}$$

Download Force on a Full Tank

$$F_D = R_1 + R_G$$

$$F_D = \frac{F}{1.414\,d}\ [\,h_L + 0.5\,h_T\,] + \frac{W_G}{4}$$

The maximum downward force (F_D) on a single weigh module equals the distributed weight of the full tank (R_G) plus the downward reaction force caused by the wind or seismic event. Compare this maximum downward force to the download rating for the weigh module being considered (see Appendix 5). If the maximum downward force is greater than the load rating, you should consider using a larger capacity weigh module to avoid overloading.

Uplift Force on an Empty Tank

$$F_U = R_1 - R_T$$

$$F_U = \frac{F}{1.414\,d}\ [\,h_L + 0.5\,h_T\,] - \frac{W_T}{4}$$

Overloading the weigh modules is not the only potential problem for tanks exposed to wind or seismic forces. You should also consider uplift forces acting on the tank. The distributed weight of an empty tank will help prevent the tank from uplifting. So the net uplift force (F_U) equals the upward reaction force minus the distributed weight of the empty tank (R_T). Compare the net uplift force (F_U) with the uplift load rating of the weigh module being considered (see Appendix 5). If the net uplift force is greater than the uplift load rating of the weigh module, you should consider using a larger capacity weigh module or installing external check rods. A negative number indicates that the weight of the empty tank is greater than the uplift force caused by the wind or seismic event.

Appendix 5: Load Ratings per Weigh Module

	Flexmount and Flexmount HD Weigh Module Capacity									
	Carbon Steel Modules						Stainless Steel Modules			
	250 to 5K[1]	10K[1]	20K and 30K[2]	45K[2]	50K, 75K, and 100K[2]	150K and 200K[2]	250 to 5K[1]	10K[1]	20K and 30K[2]	45K[2]
Allowable Side Shear	1.7K	4.7K	100%	100%	100%	100%	1K	1.3K	100%	100%
Allowable End Shear	12.4K	30.3K	100%	100%	100%	100%	7.2K	12.2K	100%	100%
Allowable Uplift	6.7K	13.3K	100%	100%	100%	100%	6.7K	13.3K	100%	100%
Allowable Download	6.7K	13.3K	150%	150%	150%	150%	6.3K	13.3K	150%	150%
Side Load Failure Rating[3]	3.5K	9.8K	32K	54K	NA	NA	2.5K[4]	7.3K[4]	32K	54K

Note: K = Kips = 1,000 pounds.

Table 14-4: Load Ratings per Flexmount Weigh Module

[1]The allowable loads per weigh module (for 250-lb to 10K-lb rated capacities) were determined by using *Allowable Stress Design* as outlined by American Institute of Steel Construction (AISC) standards. Weigh module component stresses will remain in the elastic range as long as the allowable loads are not exceeded.

[2]Percentages listed in the table (for 20K-lb to 200K-lb rated capacities) are a percent of rated capacity. These values may exceed the elastic range of some weigh module components.

[3]The side load failure ratings are listed for reference. These values were determined using a test fixture. They represent the side load at which the load cell mounting bolts shear off the base mounting plate.

[4]250-lb to 10K-lb stainless steel side load failure ratings were analytically determined.

Appendix 6: Flexmount Top Plate Travel

Flexmount weigh modules are designed to allow for the thermal expansion and contraction of the tank or other structure that is mounted on top of them. Table 14-5 lists the maximum distances that full-floating top plates can travel in any direction. These distances also apply to how far semi-floating top plates can travel in one direction only. You can use the distances listed here to determine if a weigh module will accommodate the expansion and contraction of a specific tank.

Model	Load Cell Capacity	T1	T2
0958 Flexmount	250 lb to 5K lb (220 kg to 2,200 kg)	± 1/8 inch ± 3.18 mm	± 1/4 inch ± 6.35 mm
0958 Flexmount	10K lb (4,400 kg)	± 3/16 inch ± 4.76 mm	± 1/4 inch ± 6.35 mm
0958 Flexmount	20K lb (9,072 kg)	± 1/4 inch ± 6.35 mm	± 1/4 inch ± 6.35 mm
0958 Flexmount	30K lb (13,608 kg)	± 1/4 inch ± 6.35 mm	± 1/4 inch ± 6.35 mm
0958 Flexmount	45K lb (20,412 kg)	± 1/4 inch ± 6.35 mm	± 1/4 inch ± 6.35 mm
0958 Flexmount HD	50K lb to 200K lb	± 3/8 inch ± 9.53 mm	± 3/8 inch ± 9.53 mm

T1 = Travel distance on full-floating top plate (hold-down bolt in place)
T2 = Travel distance on full-floating top plate (hold-down bolt removed)

Table 14-5: Flexmount Top Plate Travel Distances

Appendix 7: Load Cell Deflection

Flexmount/Centerlign		Flexmount/Centerlign		Ultramount		Tension Mount		Tension Mount	
Load Cell Capacity (lb)	Deflection at Rated Capacity (inches)	Load Cell Capacity (kg)	Deflection at Rated Capacity (mm)	Load Cell Capacity (kg)	Deflection at Rated Capacity (mm)	Load Cell Capacity (lb)	Deflection at Rated Capacity (inches)	Load Cell Capacity (kg)	Deflection at Rated Capacity (mm)
250	0.010	220	0.254	5	<0.4	50	0.006	50	0.152
500	0.010	550	0.254	10	<0.4	100	0.006	100	0.152
1,250	0.010	1,100	0.254	20	<0.4	200	0.006	200	0.152
2,500	0.010	2,200	0.254	50	<0.4	300	0.007	500	0.152
5,000	0.012	4,400	0.254	100	<0.4	500	0.007	1,000	0.254
10,000	0.012	9,072	0.910	—	—	1,000	0.006	2,000	0.381
20,000	0.036	13,608	0.910	—	—	2,000	0.010	5,000	0.381
30,000	0.036	20,412	1.650	—	—	3,000	0.012	—	—
45,000	0.065	—	—	—	—	5,000	0.015	—	—
50,000*	0.020	—	—	—	—	10,000	0.015	—	—
75,000*	0.020	—	—	—	—	—	—	—	—
100,000*	0.020	—	—	—	—	—	—	—	—
150,000*	0.020	—	—	—	—	—	—	—	—
200,000*	0.020	—	—	—	—	—	—	—	—

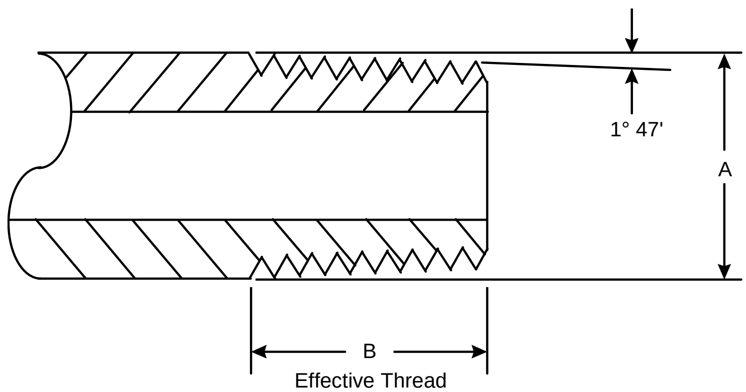
*50,000-lb to 200,000-lb capacities are used only for Flexmount HD weigh modules.

Table 14-6: Load Cell Deflection

Appendix 8: Bolt Thread Dimensions

The following tables list National Pipe Taper (NPT) dimensions and straight thread dimensions for hex head bolts.

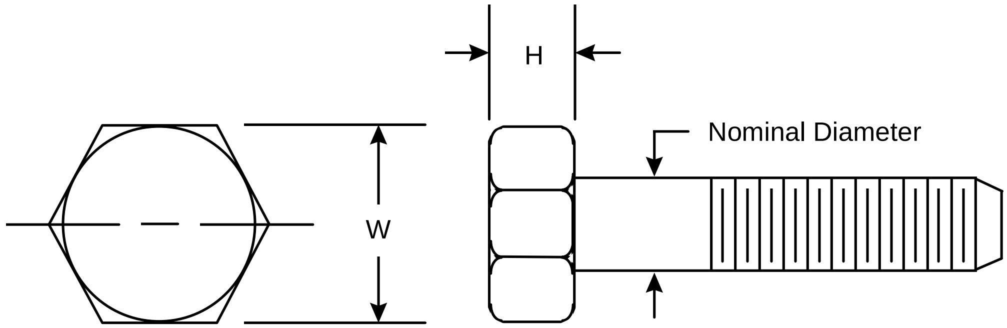
NPT Dimensions



NPT Size	Threads Per Inch	A (inches)	B (inches)
1/16	27	0.312	0.261
1/8	27	0.405	0.264
1/4	18	0.540	0.402
3/8	18	0.675	0.408
1/2	14	0.840	0.534
3/4	14	1.050	0.546
1	11 1/2	1.315	0.683
1 1/4	11 1/2	1.660	0.707

Table 14-7: NPT Dimensions

Straight Thread Dimensions



Straight Thread Dimensions (US)

Nominal Thread Size	Threads per Inch		Nominal Diameter	W (inches)	H (inches)
	Coarse (UNC)	Fine (UNF)			
6	32	40	0.1380	-	-
8	32	36	0.1640	-	-
10	24	32	0.1900	-	-
12	24	28	0.2160	-	-
1/4	20	28	0.2500	7/16	11/64
5/16	18	24	0.3125	1/2	7/32
3/8	16	24	0.3750	9/16	1/4
7/16	14	20	0.4375	5/8	19/64
1/2	13	20	0.5000	3/4	11/32
9/16	12	18	0.5625	13/16	3/8
5/8	11	18	0.6250	15/16	27/64
3/4	10	16	0.7500	1 1/8	1/2
7/8	9	14	0.8750	1 5/16	37/64
1	8	12	1.0000	1 1/2	43/64
1 1/8	7	12	1.1250	1 11/16	3/4
1 1/4	7	12	1.2500	1 7/8	27/32
1 3/8	6	12	1.3750	2 1/16	29/32
1 1/2	6	12	1.5000	2 1/4	1

Straight Thread Dimensions (Metric)

Nominal Thread Size*	Thread Pitch (mm)	Nominal Diameter	W (mm)	H (mm)
M3	0.5	3	5.5	2.125
M4	0.7	4	7.0	2.925
M5	0.8	5	8.0	3.650
M6	1	6	10.0	4.150
M8	1.25	8	13.0	5.650
M10	1.5	10	17.0	7.180
M12	1.75	12	19.0	8.180
(M14)	2	14	22.0	9.180
M16	2	16	24.0	10.180
(M18)	2.5	18	27.0	12.215
M20	2.5	20	30.0	13.215
(M22)	2.5	22	32.0	14.215
M24	3	24	36.0	15.215
(M27)	3	27	41.0	17.215
M30	3.5	30	46.0	19.260
(M33)	3.5	33	50.0	21.260
M36	4	36	55.0	23.260
(M39)	4	39	60.0	25.260

*Thread sizes shown in parentheses are not preferred.

Table 14-8: Straight Thread Dimensions

Appendix 9: Junction Box Dimensions and Wiring Diagrams

This appendix provides dimension drawings and wiring diagrams for analog, DigiTOL, and IDNet junction boxes.

Analog Junction Boxes

Note: Dimensions are shown in inches.

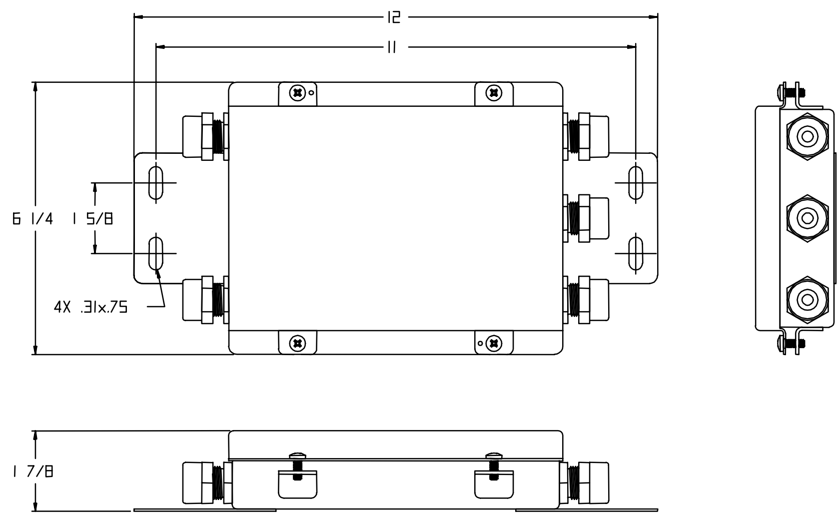


Figure 14-8: Analog Junction Box Dimensions

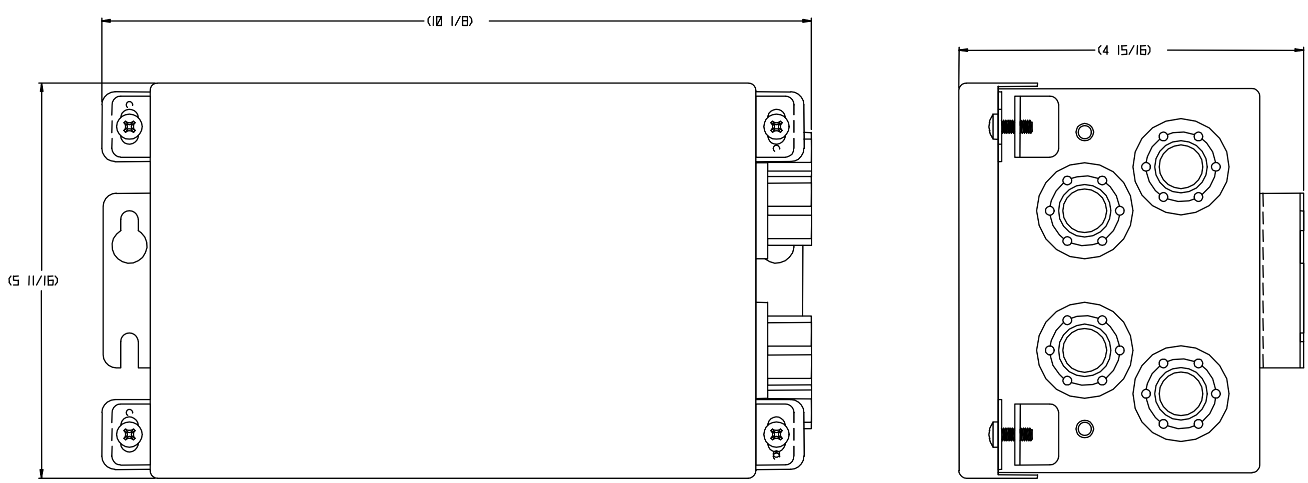


Figure 14-9: Large Analog Junction Box Dimensions

Note: Do not cut load cell cables. Cutting a cable will eliminate its shield wire and affect performance.

Note: Turn all pots fully clockwise before calibrating the scale.

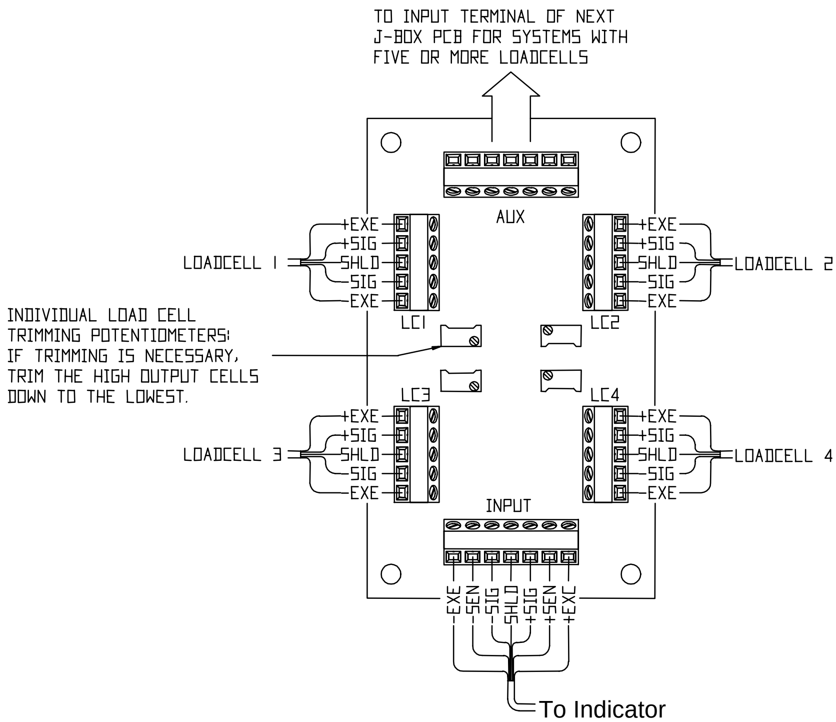


Figure 14-10: Analog Junction Box PCB Wiring

Load Cell Wiring					Indicator Wiring**	
Function	**Color for Model 743 (45K only)**	**Color for Model 777 (5-100 kg)**	**Color for Model 713**	**Color for All Other Load Cells**	**Function**	**Color**
+Excitation	White	Blue	Red	Green	+Excitation	White
+Sense	--	Green*	--	--	+Sense	Yellow
+Signal	Green	White	Green	White	+Signal	Green
Shield	Yellow	Yellow	Yellow	Yellow	Shield	Orange
-Signal	Black	Red	White	Red	-Signal	Black
-Sense	--	Gray*	--	--	-Sense	Red
-Excitation	Blue	Black	Black	Black	-Excitation	Blue

* For Model 777 load cells, connect the +Sense wire to the +Excitation terminal and the -Sense wire to the -Excitation terminal.
** Based on METTLER TOLEDO cable number 510624370.

Table 14-9: Analog Junction Box Wiring Codes

DigiTOL Junction Boxes

Note: Dimensions are shown in inches.

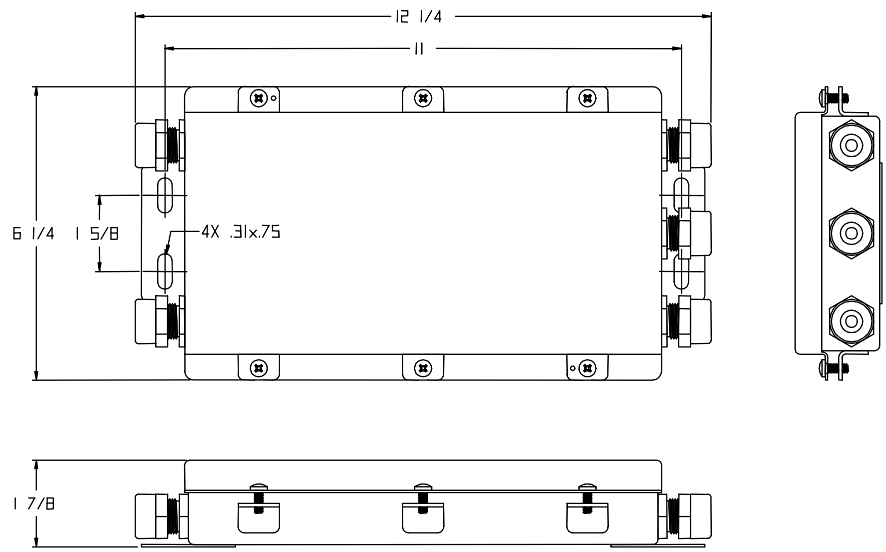


Figure 14-11: DigiTOL Junction Box Dimensions

⚠ WARNING

DO NOT USE THE DigiTOL JUNCTION BOX IN LOCATIONS CLASSIFIED AS HAZARDOUS BY THE NATIONAL ELECTRICAL CODE (NEC) ARTICLE 500.

Note: Do not cut load cell cables. Cutting a cable will eliminate its shield wire and affect performance.

Note: For 2 mV/V load cells, jumpers W1, W2, W3, and W4 must be ON (shorting the pins).

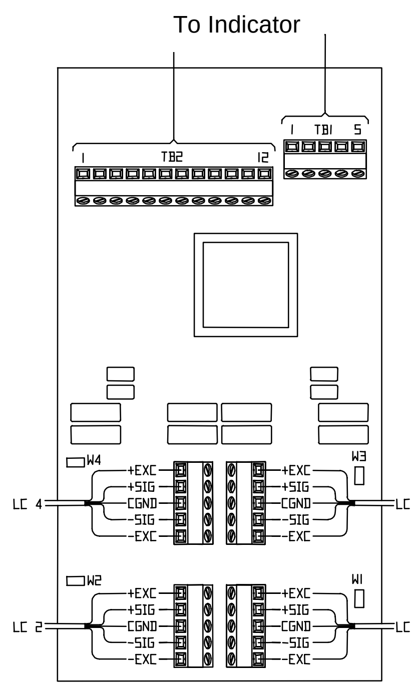


Figure 14-12: DigiTOL Junction Box PCB Wiring

Load Cell Wiring				
Function	**Color for Model 743 (45K only)**	**Color for Model 777 (5-100 kg)**	**Color for Model 713**	**Color for All Other Load Cells**
+Excitation	White	Blue	Red	Green
+Sense	--	Green*	--	--
+Signal	Green	White	Green	White
Shield	Yellow	Yellow	Yellow	Yellow
-Signal	Black	Red	White	Red
-Sense	--	Gray*	--	--
-Excitation	Blue	Black	Black	Black

* For Model 777 load cells, connect the +Sense wire to the +Excitation terminal and the -Sense wire to the -Excitation terminal.

Table 14-10: DigiTOL Junction Box Wiring Codes

Indicator Wiring			
Terminal	**Position**	**Function**	**Wire Color**
TB1	1	Shield	Orange
TB1	2	RXDA	Red
TB1	3	RXDB	White
TB1	4	TXDB	Yellow
TB1	5	TXDA	Black
TB2	10	+20VDC	Green
TB2	12	Ground	Blue

Table 14-11: DigiTOL Junction Box Wiring Codes

IDNet Junction Boxes

Note: Dimensions are shown in inches.

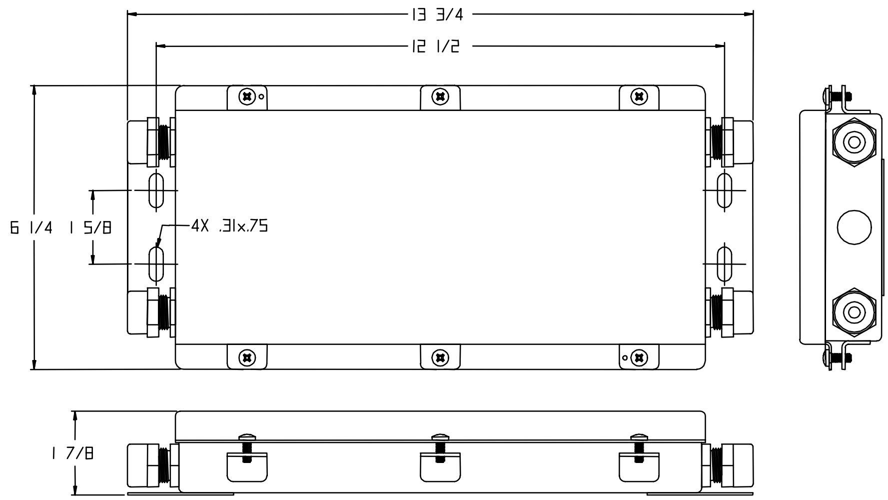


Figure 14-13: IDNet Junction Box Dimensions

⚠ WARNING

DO NOT USE THE IDNet JUNCTION BOX IN LOCATIONS CLASSIFIED AS HAZARDOUS BY THE NATIONAL ELECTRICAL CODE (NEC) ARTICLE 500.

Note: Do not cut load cell cables. Cutting a cable will eliminate its shield wire and affect performance.

Note: If shift adjustment is required, engage all trimming potentiometers by opening all eight hook latches. Start with all eight trimming potentiometers zeroed (turned fully counter clockwise), Adjust both the +Signal and -Signal trim pots for each load cell by equal amounts.

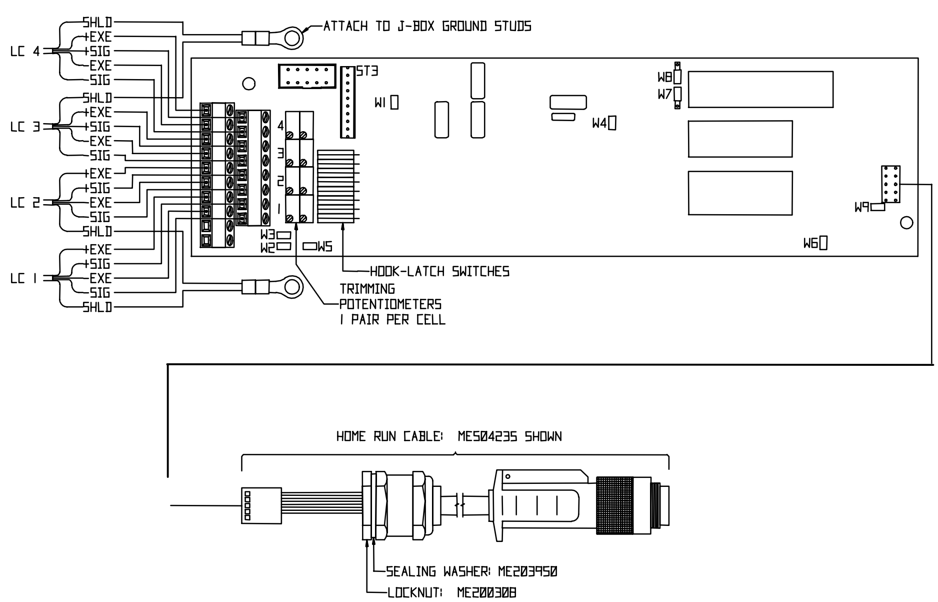


Figure 14-14: IDNet Junction Box PCB Wiring

Load Cell Wiring				
Function	**Color for Model 743 (45K only)**	**Color for Model 777 (5-100 kg)**	**Color for Model 713**	**Color for All Other Load Cells**
+Excitation	White	Blue	Red	Green
+Sense	--	Green*	--	--
+Signal	Green	White	Green	White
Shield	Yellow	Yellow	Yellow	Yellow
-Signal	Black	Red	White	Red
-Sense	--	Gray*	--	--
-Excitation	Blue	Black	Black	Black

* For Model 777 load cells, connect the +Sense wire to the +Excitation terminal and the -Sense wire to the -Excitation terminal.

Table 14-12: IDNet Junction Box Wiring Codes

Note: For 2 mV/V load cells, jumpers W1, W2, W3, and W4 must be ON (shorting the pins).

Jumper	Status	Description
W1	Closed (ON)	Matching the gain at 2 mV/V load cells
W2	Closed (ON)	No external sensing (-Sense)
W3	Closed (ON)	No external sensing (+Sense)
W4	Closed (ON)	Internal reference voltage = 3.5 volts
W5	Open (OFF)	Excitation voltage for load cells = 4.0 volts
W6	Closed (ON)	Internal supply voltage = 7.1 volts
W7	2-3	Protocol IDNet
W8	1-2	Interface 20 mA
W9	Open (OFF)	Supply voltage IDNet
SA1	Closed (ON)	Trim potentiometers circuit disabled

Table 14-13: IDNet Junction Box Default Factory Setting

Appendix 10: NEMA/IP Enclosure Types

The National Electrical Manufacturers Association (NEMA) provides descriptions, classifications, and test criteria relating to enclosures for electrical equipment. Tables 14-14, 14-15, and 14-16 compare the specific applications of enclosures for indoor and outdoor nonhazardous locations and indoor hazardous locations.

Provides a Degree of Protection Against the Following Environmental Conditions	Type of Enclosure									
	1*	2*	4	4X	5	6	6P	12	12K	13
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing		X	X	X	X	X	X	X	X	X
Circulating dust, lint, fibers, and flyings**			X	X		X	X	X	X	X
Settling airborne dust, lint, fibers, and flyings**			X	X	X	X	X	X	X	X
Hosedown and splashing water			X	X		X	X			
Oil and coolant seepage								X	X	X
Oil or coolant spraying and splashing										X
Corrosive agents				X			X			
Occasional temporary submersion						X	X			
Occasional prolonged submersion							X			

*These enclosures may be ventilated. However, Type 1 may not provide protection against small particles of falling dirt when ventilation is provided in the enclosure top. Consult the manufacturer.

**These fibers and flyings are nonhazardous materials and are not considered Class III type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings, see the National Electrical Code, Article 500.

Table 14-14: Specific Applications of Enclosures for Indoor Nonhazardous Locations

Provides a Degree of Protection Against the Following Environmental Conditions	Type of Enclosure						
	3	3R*	3S	4	4X	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X
Rain, snow, and sleet**	X	X	X	X	X	X	X
Sleet***			X				
Windblown dust	X		X	X	X	X	X
Hosedown				X	X	X	X
Corrosive agents					X		X
Occasional temporary submersion						X	X
Occasional prolonged submersion							X

*These enclosures may be ventilated.

**External operating mechanisms are not required to be operable when the enclosure is ice covered.

***External operating mechanisms are operable when the enclosure is ice covered.

Table 14-15: Specific Applications of Enclosures for Outdoor Nonhazardous Locations

Provides a Degree of Protection Against Atmospheres Typically Containing:*		Type 7 and 8 Enclosures**				Type 9 Enclosures**			Type 10
	Class	A	B	C	D	E	F	G	10
Acetylene	I	X							
Hydrogen, manufactured gas	I		X						
Diethyl ether, ethylene, cyclopropane	I			X					
Gasoline, hexane, butane, naphtha, propane, acetone, toluene, isoprene	I				X				
Metal dust	II					X			
Carbon black, coal dust, coke dust	II						X		
Flour, starch, grain dust	II							X	
Fibers, flyings***	III							X	
Methane with or without coal dust	MSHA								X

*For complete listing, see NFPA 497M-1986, Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations.

**For Class III type ignitable fibers or combustible flyings, see the National Electrical Code, Article 500.

***Due to the characteristics of the gas, vapor, or dust, a product suitable for one Class or Group may not be suitable for another Class or Group unless so marked on the product.

Table 14-16: Specific Applications of Enclosures for Indoor Hazardous Locations

Tables 14-17 and 14-18 describe the features each enclosure is expected to have and the tests applied to each.

NEMA Type	Description	Requirements/Design Tests
1	Indoor use primarily to provide a degree of protection against limited amounts of falling dirt.	Rod Entry, Rust Resistance
2	Indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.	Rod Entry, Rust Resistance, Drip
3	Outdoor use primarily to provide a degree of protection against windblown dust, rain, sleet, and external ice formation.	Rain, Outdoor Dust, External Icing, Corrosion Protection
3R	Outdoor use primarily to provide a degree of protection against falling rain, sleet, and external ice formation.	Rod Entry, Rain, External Icing, Corrosion Protection
3S	Outdoor use primarily to provide a degree of protection against windblown dust, rain, sleet, and to provide for operation of external mechanisms when ice laden.	Rain, Outdoor Dust, External Icing, Corrosion Protection
4	Indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water, and external ice formation.	External Icing, Hosedown, Corrosion Protection
4X	Indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water, and external ice formation.	External Icing, Hosedown, Corrosion Protection
5	Indoor use primarily to provide a degree of protection against settling airborne dust, falling dirt, and dripping noncorrosive liquids.	Drip, Settling Airborne Dust, Rust Resistance
6	Indoor or outdoor use primarily to provide a degree of protection against hose-directed water, and the entry of water during occasional temporary submersion at a limited depth.	Submersion, External Icing, Hosedown, Corrosion Protection
6P	Indoor or outdoor use primarily to provide a degree of protection against hose-directed water, and the entry of water during prolonged submersion at a limited depth.	Air Pressure, External Icing, Hosedown, Corrosion Protection
12	Indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids.	Drip, Circulating Dust, Rust Resistance
12K	Indoor use (with knockouts) primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids other than at knockouts.	Drip, Circulating Dust, Rust Resistance
13	Indoor use primarily to provide a degree of protection against lint, dust, spraying of water, oil, and noncorrosive coolant.	Rust Resistance, Oil Exclusion

Table 14-17: Nonhazardous Area Enclosures

NEMA Type	Description	Requirements/Design Tests*
7	Indoor use in locations classified as Class I, Groups A, B, C, and D, as defined in the National Electrical Code.	ANSI/UL 698, ANSI/UL 877, ANSI/UL 886, ANSI/UL 894
8	Indoor or outdoor use in locations classified as Class I, Groups A, B, C, and D, as defined in the National Electrical Code.	ANSI/UL 698, ANSI/UL 877, Rain
9	Indoor use in locations classified as Class II, Groups E, F, and G, as defined in the National Electrical Code.	ANSI/UL 698, ANSI/UL 877, ANSI/UL 886, ANSI/UL 894
10	Constructed to meet the applicable requirements of the Mine Safety and Health Administration.	In accordance with the Mine Safety and Health Administration
*ANSI/UL 698, Industrial Control Equipment for Use in Hazardous Locations. ANSI/UL 877, Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G. ANSI/UL 886, Outlet Boxes and Fittings for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G. ANSI/UL 894, Switches for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G.		

Table 14-18: Hazardous Area Enclosures

The International Electrotechnical Commission (IEC) provides international classifications (IP Codes) of enclosures for electrical equipment. Table 14-19 can be used to convert NEMA Enclosure Type Numbers to IEC Enclosure Classification Designations. However, since NEMA Types meet or exceed the test requirements for the IEC Classifications, this table cannot be used to convert IEC Classifications to NEMA Types.

NEMA Enclosure Type Number	IEC Enclosure Classification Designation
1	IP10
2	IP11
3	IP54
3R	IP14
3S	IP54
4 and 4X	IP56
5	IP52
6 and 6P	IP67
12 and 12K	IP52
13	IP54

Table 14-19: Conversion of NEMA Type Numbers to IEC Classification Designations

Table 14-20 provides a brief description of the IP Code elements. Full details are specified in the clauses listed in the last column.

Element	Numerals or Letters	Meaning for the Protection of Equipment	Meaning for the Protection of Persons	Reference
Code Letters	IP	—	—	—
First characteristic numeral		Protection against ingress of solid foreign objects:	Protection against access to hazardous parts with:	Cl. 5
	0	• (not protected)	• (not protected)	
	1	• $\geq$ 50 mm diameter	• back of hand	
	2	• $\geq$ 12.5 mm diameter	• finger	
	3	• $\geq$ 2.5 mm diameter	• tool	
	4	• $\geq$ 1.0 mm diameter	• wire	
	5	• dust protected	• wire	
	6	• dust tight	• wire	
Second characteristic numeral		Protection against ingress of water with harmful effects:	—	Cl. 6
	0	• (not protected)		
	1	• vertically dripping		
	2	• dripping (15° tilted)		
	3	• spraying		
	4	• splashing		
	5	• jetting		
	6	• powerful jetting		
	7	• temporary immersion		
	8	• continuous immersion		
Additional letter (optional)		—	Protection against access to hazardous parts with:	Cl. 7
	A		• back of hand	
	B		• finger	
	C		• tool	
	D		• wire	
Supplementary letter (optional)		Supplementary information specific to:	—	Cl. 8
	H	• high-voltage apparatus		
	M	• motion during water test		
	S	• stationary during water test		
	W	• weather conditions		

Table 14-20: Elements of the IP Code

Appendix 11: Engineering Specifications

This appendix contains engineering specifications for Model 0958 Flexmount weigh modules, Model 0958 Flexmount HD weigh Modules, Model 0958 Centerlign weigh modules, Model 0972 Ultramount weigh modules, Model VLM2 Value Line weigh modules, and Model 0978 Tension weigh modules.

Flexmount Weigh Modules

The portions of this specification that have been left blank (___________) should be filled with information about the specific application. Information for the blanks in Sections 1.1 and 5.3.11 can be found in Table 14-21 (Table 14-23 for OIML applications). Information for the blanks in Sections 5.3.1 to 5.3.9 can be found in Table 14-22 (Table 14-24 for OIML applications). If carbon steel weigh modules are specified in Section 1.1, use the Material and Finish Specifications for carbon steel weigh modules (Section 3). If stainless steel weigh modules are specified in Section 1.1, use the Material and Finish Specifications for stainless steel weigh modules (Section 4).

1 General Provisions

1.1 Provide a complete system consisting of ______ (qty) ______ lb/kg ________________ (carbon steel or stainless steel) weigh modules to convert a freestanding structure into a scale.

1.2 Each module shall include load cell, top and bottom mounting plates, self-aligning suspension, and anti-lift restraints.

1.3 The system shall include a stainless steel NEMA 4X/IP65 summing junction box.

1.4 Each weigh module shall be completely factory assembled.

2 Mechanical Specifications

2.1 The system shall be completely self-checking. No additional check rods, links, or stays are required.

2.2 One module of the system shall be of a fixed-pin design so that all vessel movements, including those caused by thermal expansion and contraction, will be relative to that point. The influence of any plumbing (inlet/outlet pipes, etc.) attached to the vessel at the fixed-pin location shall have a minimal influence on weigh vessel accuracy.

2.3 One module of the system shall be of a semi-floating design to allow for movement of the vessel due to thermal expansion toward and away from the fixed-pin module. This module shall also provide anti-rotational vessel checking in a horizontal plane.

2.4 All remaining modules shall be of a full-floating design, allowing the top mounting plates to move laterally in all directions without imposing a side force on the cells, which would produce weighing errors.

2.5 The load point on each load cell shall remain stationary. Modules shall be designed to allow movement of the module top mounting plate without changing the load point on the load cell, or allowing the load introduction mechanism between the top plate and the load cell to be out of a vertical position. Load cells which allow movement of the load point on the load cell are not acceptable.

2.6 The load introduction mechanism between the top plate and the load cell shall be a pin design constructed of hardened 17-4ph stainless steel. The load pin shall have an O-ring seal at one end to prevent dirt and other foreign material from entering the load cell bearing surface. Direct bolt connections between the top mounting plate and the load cell are not acceptable.

2.7 Each module shall be equipped with an integral hold-down bolt designed to prevent the vessel from being uplifted off the weigh module.

2.8 The hold-down bolt shall serve as an alignment tool to correctly position the top mounting plate over the load cell during installation.

2.9 The hold-down bolt shall secure the top plate during shipping and installation. It shall be capable of taking the load off the load cell to protect the load cell from possible shock during shipping and installation. In addition, the hold-down bolt shall facilitate load cell replacement by serving as a jacking device for the empty vessel.

3 Material and Finish Specification (for Carbon Steel Weigh Modules)

3.1 Load cells and load pins shall be made of hardened 17-4ph stainless steel.

3.2 Top and bottom mounting plates shall be abrasive blasted to 1.5 to 2.5 mils profile per SSPC-SP10 (Near White Blast).

3.3 Mounting plates shall be painted with Carboline 890 high-build epoxy enamel. Coating must be cured to 3-6 mils DFT.

3.4 Coating must meet USDA regulations for incidental food contact.

3.5 Coating shall be lead and chromate free and cannot contain any substance defined as carcinogenic by the U.S. EPA.

3.6 Coating must be suitable for salt solution immersion.

3.7 Coating must be chemical resistant per ASTM D3912 (Splash, Spillage, and Fumes).

4 Material and Finish Specification (for Stainless Steel Weigh Modules)

4.1 Load cells and load pins shall be made of hardened 17-4ph stainless steel.

4.2 Top and bottom mounting plates shall be made of type 304 stainless steel and have an electro-polished finish.

5 Load Cell Specifications

5.1 All load cells shall meet or exceed the National Institute of Standards and Technology (NIST) Handbook 44 for Class III weighing devices and shall be certified by the National Type Evaluation Program (NTEP) for 3,000 division Class III accuracy.

5.2 OIML load cells can be offered as an option.

5.3 Load cells shall have the following individual characteristics:

5.3.1 Rated Capacity (R.C.): ____________

5.3.2 Rated Output: ____________

5.3.3 Zero Balance: ____________

5.3.4 Combined Error Due To Non-Linearity & Hysteresis: ____________

5.3.5 Non-Repeatability: ____________

5.3.6 Temperature Compensation: ____________

5.3.7 Terminal Resistance
Input: ____________
Signal: ____________

5.3.8 Excitation Voltage: ____________

5.3.9 Insulation Resistance: ____________

5.3.10 Maximum Loads

Safe Overload:	150% of R.C.
Ultimate Overload:	300% of R.C.
Safe Side Load:	100% of R.C.

5.3.11 Gauge Cavity & Wiring Seal Type: ____________
(potted or hermetic) seal

5.4 Each load cell shall have an integral conduit fitting on the cable entrance into the load cell for enhanced moisture protection.

5.5 Each load cell shall have a data plate affixed to the load cell which clearly shows:

5.5.1 Manufacturer

5.5.2 Capacity

5.5.3 Part Number

5.5.4 Serial Number

5.5.5 Class Number

5.5.6 NTEP Certificate of Conformance Number

5.5.7 Maximum Divisions (Nmax)

5.5.8 Load Cell Vmin

5.6 Load cells shall be mounted to the base plate with high strength grade 5 bolts minimum.

6 Junction Box Specifications

6.1 Junction box enclosure shall be constructed of type 304 stainless steel and shall be designed to NEMA 4X/IP65 standards.

6.2 The junction box enclosure shall have washdown duty connectors, one for each load cell cable, and one additional connector for the instrument cable. Multiple cables using single box connectors are not acceptable.

6.3 The junction box shall contain a printed circuit board for the purpose of individual load cell wiring termination, summing of the output signals from each load cell, trimming/balancing the load cell signals, and wiring the interface to the digital instrument.

6.4 The printed circuit board shall have individual connectors for each of the load cells, and the instrument interface cable. Each wire shall have a single terminal connection. Doubling up or ganging of wires to one terminal is not acceptable.

6.5 The summing printed circuit board shall have potentiometers, one per load cell for the electrical trimming/balancing of the load cell signals during calibration.

7 Warranty

7.1 The product shall be free from defects in workmanship and materials for a period of 1 year from date of original installation, or 18 months from the date of shipment to the original buyer, whichever occurs first. The manufacturer shall cover technician travel time and mileage costs for the first 30 days after installation, with on-site labor and replacement parts covered for the first 12 months after installation.

8 Acceptable Manufacturers

8.1 Scale system shall be METTLER TOLEDO Flexmount Weigh Modules.

NIST System Specifications					
Qty.*	Load Cell Capacity (lb)	System Capacity (lb)	Cable Length (ft)	Conduit Fitting	(H)ermetic (P)otted
3	250	750	15	1/4-18 NPT	P
4	250	1,000	15	1/4-18 NPT	P
3	500	1,500	15	1/4-18 NPT	H
4	500	2,000	15	1/4-18 NPT	H
3	1,250	3,750	15	1/4-18 NPT	H
4	1,250	5,000	15	1/4-18 NPT	H
3	2,500	7,500	15	1/4-18 NPT	H
4	2,500	10,000	15	1/4-18 NPT	H
3	5,000	15,000	15	1/4-18 NPT	H
4	5,000	20,000	15	1/4-18 NPT	H
3	10,000	30,000	30	1/4-18 NPT	H
4	10,000	40,000	30	1/4-18 NPT	H
3	20,000	60,000	30	1/4-18 NPT	H
4	20,000	80,000	30	1/4-18 NPT	H
3	30,000	90,000	30	1/4-18 NPT	H
4	30,000	120,000	30	1/4-18 NPT	H
3	45,000	135,000	30	1/4-18 NPT	H
4	45,000	180,000	30	1/4-18 NPT	H

*System configurations of five or more modules are possible.

Table 14-21: NIST Weigh Module System Specifications (Flexmount)

NIST Load Cell Specifications			
Rated Capacity of Load Cell (lb)	250*, 500, 1,250, 2,500, 5,000, 10,000	20,000, 30,000	45,000
Rated Output	2.0 ± 0.002 mV/V	2.0 ± 0.005 mV/V	2.0 ± 0.005 mV/V
Zero Balance	± 0.02 mV/V	± 1.5% of R.C.	± 1.5% of R.C.
Combined Error Due to Non-Linearity and Hysteresis	0.03% of R.C.	0.02% of R.C.	0.02% of R.C.
Non-Repeatability	0.01% of R.C.	0.01% of R.C.	0.01% of R.C.
Temperature Compensation	-10° to +40° C +14° to +104° F	-10° to +40° C +14° to +104° F	-10° to +40° C +14° to +104° F
Terminal Resistance	Input: 385Ω Signal: 350Ω ±2Ω	Input: 380Ω ±20Ω Signal: 350Ω ±2Ω	Input: 2,200Ω ±100Ω, Signal: 2,000Ω ±20Ω
Excitation Voltage	15 VDC maximum	20 VDC maximum	20 VDC maximum
Insulation Resistance	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

*250-lb load cell is not NTEP Certified.

Table 14-22: NIST Load Cell Specifications (Flexmount)

OIML System Specifications					
Qty.*	Load Cell Capacity (kg)	System Capacity (kg)	Cable Length (m)	Conduit Fitting	(H)ermetic Cell (P)otted Cell
3	220	660	4.57	1/4-18 NPT	H
4	220	880	4.57	1/4-18 NPT	H
3	550	1,650	4.57	1/4-18 NPT	H
4	550	2,200	4.57	1/4-18 NPT	H
3	1,100	3,300	4.57	1/4-18 NPT	H
4	1,100	4,400	4.57	1/4-18 NPT	H
3	2,200	6,600	4.57	1/4-18 NPT	H
4	2,200	8,800	4.57	1/4-18 NPT	H
3	4,400	13,200	9.14	1/4-18 NPT	H
4	4,400	17,600	9.14	1/4-18 NPT	H
3	9,072	27,216	9.14	1/4-18 NPT	H
4	9,072	36,288	9.14	1/4-18 NPT	H
3	13,608	40,824	9.14	1/4-18 NPT	H
4	13,608	54,432	9.14	1/4-18 NPT	H
3	20,412	61,236	9.14	1/4-18 NPT	H
4	20,412	81,648	9.14	1/4-18 NPT	H

*System configurations of five or more modules are possible.

Table 14-23: OIML Weigh Module System Specifications (Flexmount)

OIML Load Cell Specifications			
Rated Capacity of Load Cell (kg)	220, 550, 1,100, 2,200, 4,400	9,072, 13,608	20,412
Rated Output	1.94 ± 0.002 mV/V	2.0 ± 0.005 mV/V	2.0 ± 0.005 mV/V
Zero Balance (% of rated output)	1.0	1.0	1.0
Combined Error Due to Non-Linearity and Hysteresis	0.017% of R.C.	0.02% of R.C.	0.02% of R.C.
Non-Repeatability	0.01% of R.C.	0.01% of R.C.	0.01% of R.C.
Temperature Compensation	-10° to +40° C	-10° to +40° C	-10° to +40° C
Terminal Resistance	Input: 385Ω Signal: 350Ω ±2Ω	Input: 380Ω ±20Ω Signal: 350Ω ±2Ω	Input: 2,200Ω ±100Ω Signal: 2,200Ω ±20Ω
Excitation Voltage	15 VDC maximum	15 VDC maximum	15 VDC maximum
Insulation Resistance	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

Table 14-24: OIML Load Cell Specifications (Flexmount)

Flexmount HD Weigh Modules

The portions of this specification that have been left blank (__________) should be filled with information about the specific application. Information for the blanks in Section 1.1 can be found in Table 14-25. Information for the blanks in Sections 4.2.1 to 4.2.9 can be found in Table 14-26.

1 General Provisions

1.1 Provide a complete system consisting of ______ (qty) ______ lb carbon steel weigh modules to convert a freestanding structure into a scale.

1.2 Each module shall include load cell, top and bottom mounting plates, self-aligning suspension, and anti-lift restraints.

1.3 The system shall include a stainless steel NEMA 4X/IP65 summing junction box.

1.4 Each weigh module shall be completely factory assembled.

2 Mechanical Specifications

2.1 The system shall be completely self-checking. No additional check rods, links, or stays are required.

2.2 One module of the system shall be of a fixed-pin design so that all vessel movements, including those caused by thermal expansion and contraction, will be relative to that point. The influence of any plumbing (inlet/outlet pipes, etc.) attached to the vessel at the fixed-pin location shall have a minimal influence on weigh vessel accuracy.

2.3 One module of the system shall be of a semi-floating design to allow for movement of the vessel due to thermal expansion toward and away from the fixed-pin module. This module shall also provide anti-rotational vessel checking in a horizontal plane.

2.4 All remaining modules shall be of a full-floating design, allowing the top mounting plates to move laterally in all directions without imposing a side force on the cells, which would produce weighing errors.

2.5 The load point on each load cell shall remain stationary. Modules shall be designed to allow movement of the module top mounting plate without changing the load point on the load cell, or allowing the load introduction mechanism between the top plate and the load cell to be out of a vertical position. Load cells which allow movement of the load point on the load cell are not acceptable.

2.6 The load introduction mechanism between the top plate and the load cell shall be a pin design constructed of hardened 17-4ph stainless steel. The load pin shall have an O-ring seal at one end to prevent dirt and other foreign material from entering the load cell bearing surface. Direct bolt connections between the top mounting plate and the load cell are not acceptable.

2.7 Each module shall be equipped with two integral hold-down bolts designed to prevent the vessel from being uplifted off the weigh module.

2.8 The hold-down bolts shall serve as alignment tools to correctly position the top mounting plate over the load cell during installation.

2.9 The hold-down bolts shall secure the top plate during shipping and installation. They shall be capable of taking the load off the load cell to protect the load cell from possible shock during shipping and installation. In addition, the hold-down bolts shall facilitate load cell replacement by serving as a jacking device for the empty vessel.

2.10 Module assembly shall withstand force equal to 100% of the rated capacity in any horizontal or vertical plane without mechanical failure.

3 Material and Finish Specification

3.1 Load cells shall be made of E4340 alloy tool steel and load pins shall be made of hardened 17-4ph stainless steel.
3.2 Top and bottom mounting plates shall be abrasive blasted to 1.5 to 2.5 mils profile per SSPC-SP10 (Near White Blast).
3.3 Mounting plates shall be painted with Carboline 890 high-build epoxy enamel. Coating must be cured to 3-6 mils DFT.
3.4 Coating must meet USDA regulations for incidental food contact.
3.5 Coating shall be lead and chromate free and cannot contain any substance defined as carcinogenic by the U.S. EPA.
3.6 Coating must be suitable for salt solution immersion.
3.7 Coating must be chemical resistant per ASTM D3912 (Splash, Spillage, and Fumes).

4 Load Cell Specifications

4.1 All load cells shall meet or exceed the National Institute of Standards and Technology (NIST) Handbook 44 for Class IIIL weighing devices and shall be certified by the National Type Evaluation Program (NTEP) for 10,000 division Class IIIL accuracy.
4.2 Load cells shall have the following individual characteristics:

4.2.1	Rated Capacity (R.C.):	____________
4.2.2	Rated Output:	____________
4.2.3	Zero Balance:	____________
4.2.4	Combined Error Due To Non-Linearity & Hysteresis:	____________
4.2.5	Non-Repeatability:	____________
4.2.6	Temperature Compensation:	____________
4.2.7	Terminal Resistance	
	Input:	____________
	Signal:	____________
4.2.8	Excitation Voltage:	____________
4.2.9	Insulation Resistance:	____________
4.2.10	Maximum Loads	
	Safe Overload:	150% of R.C.
	Ultimate Overload:	300% of R.C.
	Safe Side Load:	100% of R.C.

4.3 Each load cell shall have an environmentally sealed strain gauge cavity.
4.4 Each load cell shall have an integral conduit fitting on the cable entrance into the load cell for enhanced moisture protection.
4.5 Each load cell shall have a data plate affixed to the load cell which clearly shows:
- 4.5.1 Manufacturer
- 4.5.2 Capacity
- 4.5.3 Part Number
- 4.5.4 Serial Number
- 4.5.5 Class Number
- 4.5.6 NTEP Certificate of Conformance Number
- 4.5.7 Maximum Divisions (Nmax)
- 4.5.8 Load Cell Vmin

4.6 Load cells shall be mounted to the base plate with high strength grade 5 bolts minimum.

5 Junction Box Specifications

5.1 Junction box enclosure shall be constructed of type 304 stainless steel and shall be designed to NEMA 4X/IP65 standards.

5.2 The junction box enclosure shall have washdown duty connectors, one for each load cell cable, and one additional connector for the instrument cable. Multiple cables using single box connectors are not acceptable.

5.3 The junction box shall contain a printed circuit board for the purpose of individual load cell wiring termination, summing of the output signals from each load cell, trimming/balancing the load cell signals, and wiring the interface to the digital instrument.

5.4 The printed circuit board shall have individual connectors for each of the load cells, and the instrument interface cable. Each wire shall have a single terminal connection. Doubling up or ganging of wires to one terminal is not acceptable.

5.5 The summing printed circuit board shall have potentiometers, one per load cell for the electrical trimming/balancing of the load cell signals during calibration.

6 Warranty

6.1 The product shall be free from defects in workmanship and materials for a period of 1 year from date of original installation, or 18 months from the date of shipment to the original buyer, whichever occurs first. The manufacturer shall cover technician travel time and mileage costs for the first 30 days after installation, with on-site labor and replacement parts covered for the first 12 months after installation.

7 Acceptable Manufacturers

7.1 Scale system shall be METTLER TOLEDO Flexmount HD Weigh Modules.

NIST System Specifications				
Qty.*	Load Cell Capacity (lb)	System Capacity (lb)	Cable Length (ft)	Conduit Fitting
3	50,000	150,000	35	1/4-18 NPT
4	50,000	200,000	35	1/4-18 NPT
3	75,000	225,000	35	1/4-18 NPT
4	75,000	300,000	35	1/4-18 NPT
3	100,000	300,000	35	1/4-18 NPT
4	100,000	400,000	35	1/4-18 NPT
3	150,000	450,000	35	1/4-18 NPT
4	150,000	600,000	35	1/4-18 NPT
3	200,000	600,000	35	1/4-18 NPT
4	200,000	800,000	35	1/4-18 NPT

*System configurations of five or more modules are possible.

Table 14-25: NIST Weigh Module System Specifications (Flexmount HD)

NIST Load Cell Specifications	
Rated Capacity of Load Cell (lb)	50,000, 75,000, 100,000, 150,000, 200,000
Rated Output	2.0 ± 0.02 mV/V
Zero Balance	± 1% of R.C.
Combined Error Due to Non-Linearity and Hysteresis	0.03% of R.C.
Non-Repeatability	0.01% of R.C.
Temperature Compensation	-10° to +40° C +14° to +104° F
Terminal Resistance	Input: 750Ω Signal: 700Ω ±5Ω
Excitation Voltage	18 VDC maximum
Insulation Resistance	5 GigaΩ minimum @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

Table 14-26: NIST Load Cell Specifications (Flexmount HD)

Centerlign Weigh Modules

The portions of this specification that have been left blank (__________) should be filled with information about the specific application. Information for the blanks in Sections 1.1 and 5.3.11 can be found in Table 14-27 (Table 14-29 for OIML applications). Information for the blanks in Sections 5.3.1 to 5.3.9 can be found in Table 14-28 (Table 14-30 for OIML applications). If carbon steel weigh modules are specified in Section 1.1, use the Material and Finish Specifications for carbon steel weigh modules (Section 3). If stainless steel weigh modules are specified in Section 1.1, use the Material and Finish Specifications for stainless steel weigh modules (Section 4).

1 General Provisions

1.1 Provide a complete system consisting of ______ (qty) ______ lb/kg _______________ (carbon steel or stainless steel) weigh modules to convert a freestanding structure into a scale.

1.2 Each module shall include load cell, top and bottom mounting plates, self-aligning suspension, and required installation tools.

1.3 The system shall include a stainless steel NEMA 4X/IP65 summing junction box.

1.4 Each weigh module shall be completely factory assembled.

2 Mechanical Specifications

2.1 The system shall be completely self-checking. No additional check rods, links, or stays are required.

2.2 The load point on each load cell shall remain stationary. Modules shall be designed to allow movement of the module top mounting plate without changing the load point on the load cell, or allowing the load introduction mechanism between the top plate and the load cell to be out of a vertical position. Load cells which allow movement of the load point on the load cell are not acceptable.

2.3 The load introduction mechanism between the top plate and the load cell shall be a rocker pin design constructed of hardened 17-4ph stainless steel. The load pin shall have an O-ring seal at each end to prevent dirt and other foreign material from entering the load cell bearing surface. Direct bolt connections between the top mounting plate and the load cell are not acceptable.

2.4 Each module shall include an alignment tool to accurately position the upper mounting plate relative to the load cell.

3 Material and Finish Specification (for Carbon Steel Weigh Modules)

3.1 Load cells and load pins shall be made of hardened 17-4ph stainless steel.

3.2 Top and bottom mounting plates shall be abrasive blasted to 1.5 to 2.5 mils profile per SSPC-SP10 (Near White Blast).

3.3 Mounting plates shall be painted with Carboline 890 high-build epoxy enamel. Coating must be cured to 3-6 mils DFT.

3.4 Coating must meet USDA regulations for incidental food contact.

3.5 Coating shall be lead and chromate free and cannot contain any substance defined as carcinogenic by the U.S. EPA.

3.6 Coating must be suitable for salt solution immersion.

3.7 Coating must be chemical resistant per ASTM D3912 (Splash, Spillage, and Fumes).

4 Material and Finish Specification (for Stainless Steel Weigh Modules)

4.1 Load cells and load pins shall be made of hardened 17-4ph stainless steel.

4.2 Top and bottom mounting plates shall be made of type 304 stainless steel and have an electro-polished finish.

5 Load Cell Specifications

5.1 All load cells shall meet or exceed the National Institute of Standards and Technology (NIST) Handbook 44 for Class III weighing devices and shall be certified by the National Type Evaluation Program (NTEP) for 3,000 division Class III accuracy.

5.2 OIML load cells can be offered as an option.

5.3 Load cells shall have the following individual characteristics:

- 5.3.1 Rated Capacity (R.C.): ____________
- 5.3.2 Rated Output: ____________
- 5.3.3 Zero Balance: ____________
- 5.3.4 Combined Error Due To Non-Linearity & Hysteresis: ____________
- 5.3.5 Non-Repeatability: ____________
- 5.3.6 Temperature Compensation: ____________
- 5.3.7 Terminal Resistance
  - Input: ____________
  - Signal: ____________
- 5.3.8 Excitation Voltage: ____________
- 5.3.9 Insulation Resistance: ____________
- 5.3.10 Maximum Loads
  - Safe Overload: 150% of R.C.
  - Ultimate Overload: 300% of R.C.
  - Safe Side Load: 100% of R.C.
- 5.3.11 Gauge Cavity & Wiring Seal Type: ____________ (potted or hermetic) seal

5.4 Each load cell shall have an integral conduit fitting on the cable entrance into the load cell for enhanced moisture protection.

5.5 Each load cell shall have a data plate affixed to the load cell which clearly shows:

- 5.5.1 Manufacturer
- 5.5.2 Capacity
- 5.5.3 Part Number
- 5.5.4 Serial Number
- 5.5.5 Class Number
- 5.5.6 NTEP Certificate of Conformance Number
- 5.5.7 Maximum Divisions (Nmax)
- 5.5.8 Load Cell Vmin

5.6 Load cells shall be mounted to the base plate with high strength grade 5 bolts minimum.

6 Junction Box Specifications

6.1 Junction box enclosure shall be constructed of type 304 stainless steel and shall be designed to NEMA 4X/IP65 standards.

6.2 The junction box enclosure shall have washdown duty connectors, one for each load cell cable, and one additional connector for the instrument cable. Multiple cables using single box connectors are not acceptable.

6.3 The junction box shall contain a printed circuit board for the purpose of individual load cell wiring termination, summing of the output signals from each load cell, trimming/balancing the load cell signals, and wiring the interface to the digital instrument.

6.4 The printed circuit board shall have individual connectors for each of the load cells, and the instrument interface cable. Each wire shall have a single terminal connection. Doubling up or ganging of wires to one terminal is not acceptable.

6.5 The summing printed circuit board shall have potentiometers, one per load cell for the electrical trimming/balancing of the load cell signals during calibration.

7 Warranty

7.1 The product shall be free from defects in workmanship and materials for a period of 1 year from date of original installation, or 18 months from the date of shipment to the original buyer, whichever occurs first. The manufacturer shall cover technician travel time and mileage costs for the first 30 days after installation, with on-site labor and replacement parts covered for the first 12 months after installation.

8 Acceptable Manufacturers

8.1 Scale system shall be METTLER TOLEDO Centerlign Weigh Modules.

NIST System Specifications					
Qty.*	**Load Cell Capacity (lb)**	**System Capacity (lb)**	**Cable Length (ft)**	**Conduit Fitting**	**(H)ermetic (P)otted**
4	250	1,000	15	1/4-18 NPT	P
4	500	2,000	15	1/4-18 NPT	H
4	1,250	5,000	15	1/4-18 NPT	H
4	2,500	10,000	15	1/4-18 NPT	H
4	5,000	20,000	15	1/4-18 NPT	H
4	10,000	40,000	30	1/4-18 NPT	H
4	20,000	80,000	30	1/4-18 NPT	H
4	30,000	120,000	30	1/4-18 NPT	H
4	45,000	180,000	30	1/4-18 NPT	H

*System configurations using other than four modules are possible.

Table 14-27: NIST Weigh Module System Specifications (Centerlign)

NIST Load Cell Specifications			
Rated Capacity of Load Cell (lb)	250*, 500, 1,250, 2,500, 5,000, 10,000	20,000, 30,000	45,000
Rated Output	2.0 ± 0.002 mV/V	2.0 ± 0.005 mV/V	2.0 ± 0.005 mV/V
Zero Balance	± 0.02 mV/V	± 1.5% of R.C.	± 1.5% of R.C.
Combined Error Due to Non-Linearity and Hysteresis	0.03% of R.C.	0.02% of R.C.	0.02% of R.C.
Non-Repeatability	0.01% of R.C.	0.01% of R.C.	0.01% of R.C.
Temperature Compensation	-10° to +40° C +14° to +104° F	-10° to +40° C +14° to +104° F	-10° to +40° C +14° to +104° F
Terminal Resistance	Input: 385Ω Signal: 350Ω ±2Ω	Input: 380Ω ±20Ω Signal: 350Ω ±2Ω	Input: 2,200Ω ±100Ω Signal: 2,000Ω ±20Ω
Excitation Voltage	15 VDC maximum	20 VDC maximum	20 VDC maximum
Insulation Resistance	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

*250-lb load cell is not NTEP Certified.

Table 14-28: NIST Load Cell Specifications (Centerlign)

OIML System Specifications					
Qty.*	**Load Cell Capacity (kg)**	**System Capacity (kg)**	**Cable Length (m)**	**Conduit Fitting**	**(H)ermetic Cell (P)otted Cell**
4	220	880	4.57	1/4-18 NPT	H
4	550	2,200	4.57	1/4-18 NPT	H
4	1,100	4,400	4.57	1/4-18 NPT	H
4	2,200	8,800	4.57	1/4-18 NPT	H
4	4,400	17,600	9.14	1/4-18 NPT	H
4	9,072	36,288	9.14	1/4-18 NPT	H
4	13,608	54,432	9.14	1/4-18 NPT	H
4	20,412	81,648	9.14	1/4-18 NPT	H

*System configurations using other than four modules are possible.

Table 14-29: OIML Weigh Module System Specifications (Centerlign)

OIML Load Cell Specifications			
Rated Capacity of Load Cell (kg)	220, 550, 1,100, 2,200, 4,400	9,072, 13,608	20,412
Rated Output	1.94 ± 0.002 mV/V	2.0 ± 0.005 mV/V	2.0 ± 0.005 mV/V
Zero Balance (% of rated output)	1.0	1.0	1.0
Combined Error Due to Non-Linearity and Hysteresis	0.017% of R.C.	0.02% of R.C.	0.02% of R.C.
Non-Repeatability	0.01% of R.C.	0.01% of R.C.	0.01% of R.C.
Temperature Compensation	-10° to +40° C	-10° to +40° C	-10° to +40° C
Terminal Resistance	Input: 385Ω Signal: 350Ω ±2Ω	Input: 380Ω ±20Ω Signal: 350Ω ±2Ω	Input: 2,200Ω ±100Ω Signal: 2,200Ω ±20Ω
Excitation Voltage	15 VDC maximum	15 VDC maximum	15 VDC maximum
Insulation Resistance	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

Table 14-30: OIML Load Cell Specifications (Centerlign)

Ultramount Weigh Modules

Static Load Pin Suspension

The portions of this specification that have been left blank (__________) should be filled with information about the specific application. Information for the blanks in Section 1.1 can be found in Table 14-31. Information for the blanks in Sections 4.3.1 to 4.3.9 can be found in Table 14-32.

1 General Provisions

1.1 Provide a complete system consisting of ______ (qty) ______ kg stainless steel weigh modules to convert a freestanding structure into a scale.

1.2 Each module shall include load cell, top and bottom mounting plates, self-aligning suspension, and anti-lift restraints.

1.3 The system shall include a stainless steel NEMA 4X/IP65 summing junction box.

1.4 Each weigh module shall be completely factory assembled.

2 Mechanical Specifications

2.1 The system shall be completely self-checking. No additional check rods, links, or stays are required.

2.2 The system shall allow for limited lateral movements, including those caused by thermal expansion and contraction.

2.3 All modules shall be of a semi-floating design, allowing the top mounting plates to move laterally in one direction without imposing a side force on the cells. The lateral direction of travel at each module shall be adjustable by reorienting the load pin 90 degrees.

2.4 The load point on each load cell shall remain stationary. Modules shall be designed to allow movement of the module top mounting plate without changing the load point on the load cell, or allowing the load introduction mechanism between the top plate and the load cell to be out of a vertical position. Load cells which allow movement of the load point on the load cell are not acceptable.

2.5 The load introduction mechanism between the top plate and the load cell shall be a pin design constructed of hardened 17-4ph stainless steel. Direct bolt connections between the top mounting plate and the load cell are not acceptable.

2.6 Each module shall be equipped with two integral hold-down bolts designed to prevent the vessel from being uplifted off the weigh module.

2.7 The hold-down bolts shall serve as alignment tools to correctly position the top mounting plate over the load cell during installation.

2.8 The hold-down bolts shall secure the top plate during shipping and installation. They shall be capable of taking the load off the load cell to protect the load cell from possible shock during shipping and installation. In addition, the hold-down bolts shall facilitate load cell replacement by serving as jacking devices for the empty vessel.

3 Material and Finish Specification

3.1 Load cells and load pins shall be made of hardened 17-4ph stainless steel.

3.2 Top and bottom mounting plates shall be made of type 304 stainless steel and have an electro-polished finish.

4 Load Cell Specifications

4.1 All load cells shall meet or exceed the National Institute of Standards and Technology (NIST) Handbook 44 for Class III weighing devices and shall be certified by the National Type Evaluation Program (NTEP) for 5,000 division Class III accuracy.

4.2 All load cells shall be certified to meet or exceed Organisation de Metrologie Legale (OIML) C3 R60 3,000 division accuracy requirements.

4.3 Load cells shall have the following individual characteristics:

4.3.1	Rated Capacity (R.C.):	____________
4.3.2	Rated Output:	____________
4.3.3	Zero Balance:	____________
4.3.4	Combined Error Due To Non-Linearity & Hysteresis:	____________
4.3.5	Non-Repeatability:	____________
4.3.6	Temperature Compensation:	____________
4.3.7	Terminal Resistance	
	Input:	____________
	Signal:	____________
4.3.8	Excitation Voltage:	____________
4.3.9	Insulation Resistance:	____________
4.3.10	Maximum Loads	
	Safe Overload:	150% of R.C.
	Ultimate Overload:	300% of R.C.
	Safe Side Load:	100% of R.C.

4.4 Each load cell shall have a hermetically sealed strain gauge cavity.

4.5 Each load cell shall have a data plate affixed to the load cell which clearly shows:

4.5.1 Manufacturer
4.5.2 Capacity
4.5.3 Part Number
4.5.4 Serial Number
4.5.5 Class Number
4.5.6 NTEP Certificate of Conformance Number
4.5.7 Maximum Divisions (Nmax)
4.5.8 Load Cell Vmin

4.6 Load cells shall be mounted to the base plate with stainless steel socket head cap screws.

5 Junction Box Specifications

5.1 Junction box enclosure shall be constructed of type 304 stainless steel and shall be designed to NEMA 4X/IP65 standards.

5.2 The junction box enclosure shall have washdown duty connectors, one for each load cell cable, and one additional connector for the instrument cable. Multiple cables using single box connectors are not acceptable.

5.3 The junction box shall contain a printed circuit board for the purpose of individual load cell wiring termination, summing of the output signals from each load cell, trimming/balancing the load cell signals, and wiring the interface to the digital instrument.

5.4 The printed circuit board shall have individual connectors for each of the load cells, and the instrument interface cable. Each wire shall have a single terminal connection. Doubling up or ganging of wires to one terminal is not acceptable.

5.5 The summing printed circuit board shall have potentiometers, one per load cell for the electrical trimming/balancing of the load cell signals during calibration.

6 Warranty

6.1 The product shall be free from defects in workmanship and materials for a period of 1 year from date of original installation, or 18 months from the date of shipment to the original buyer, whichever occurs first. The manufacturer shall cover technician travel time and mileage costs for the first 30 days after installation, with on-site labor and replacement parts covered for the first 12 months after installation.

7 Acceptable Manufacturers

7.1 Scale system shall be METTLER TOLEDO Ultramount Weigh Modules with "load pin" suspension.

System Specifications			
Qty.*	**Load Cell Capacity (kg)**	**System Capacity (kg)**	**Cable Length (m)**
3	5	15	3
4	5	20	3
3	10	30	3
4	10	40	3
3	20	60	3
4	20	80	3
3	50	150	3
4	50	200	3
3	100	300	3
4	100	400	3

*System configurations of five or more modules are possible.

Table 14-31: Weigh Module System Specifications (Ultramount)

Load Cell Specifications	
Rated Capacity of Load Cell (kg)	5*, 10, 20, 50, 100
Rated Output	2.0 mV/V +1.0% or -0.1% (for 5 kg) 2.0 mV/V ±0.05% (for 10-100 kg)
Zero Balance	± 0.02 mV/V
Combined Error Due to Non-Linearity and Hysteresis	0.02% of R.C.
Non-Repeatability	0.01% of R.C.
Temperature Compensation	-10° to +40° C +14° to +104° F
Terminal Resistance	Input: 350Ω to 480Ω Signal: 356Ω ±0.12Ω
Excitation Voltage	18 VDC maximum
Insulation Resistance	> 1 GigaΩ @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

*5-kg load cell is NTEP Certified for 1,000d CIII, OIML Certified for 1,000d C3.

Table 14-32: Load Cell Specifications (Ultramount)

Ultramount Weigh Modules

Dynamic Ball-and-Cup Suspension

The portions of this specification that have been left blank (__________) should be filled with information about the specific application. Information for the blanks in Section 1.1 can be found in Table 14-33. Information for the blanks in Sections 4.3.1 to 4.3.9 can be found in Table 14-34.

1 General Provisions

1.1 Provide a complete system consisting of ______ (qty) ______ kg stainless steel weigh modules to convert a freestanding structure into a scale.

1.2 Each module shall include load cell, top and bottom mounting plates, self-aligning suspension, and anti-lift restraints.

1.3 The system shall include a stainless steel NEMA 4X/IP65 summing junction box.

1.4 Each weigh module shall be completely factory assembled.

2 Mechanical Specifications

2.1 The system shall be completely self-checking and self-aligning. No additional check rods, links, or stays are required.

2.2 The load point on each load cell shall remain stationary. Modules shall be designed to allow lateral movement of the module top mounting plate without changing the load point on the load cell, or allowing the load introduction mechanism between the top plate and the load cell to be out of a vertical position. Load cells which allow movement of the load point on the load cell are not acceptable.

2.3 The load introduction mechanism between the top plate and the load cell shall be a ball bearing constructed of hardened 17-4ph stainless steel. The ball bearing shall make point contact against the hardened stainless steel bearing cups. One bearing cup shall be installed in the top mounting plate and one bearing cup shall be installed in the load cell. The ball bearing suspension shall cause the top plate to realign with the load cell after encountering side loads. Direct bolt connections between the top mounting plate and the load cell are not acceptable.

2.4 Each module shall be equipped with two integral hold-down bolts designed to prevent the vessel from being uplifted off the weigh module.

2.5 The hold-down bolts shall serve as alignment tools to correctly position the top mounting plate over the load cell during installation.

2.6 The hold-down bolts shall secure the top plate during shipping and installation. They shall be capable of taking the load off the load cell to protect the load cell from possible shock during shipping and installation. In addition, the hold-down bolts shall facilitate load cell replacement by serving as jacking devices for the empty vessel.

3 Material and Finish Specification

3.1 Load cells and bearing cups shall be made of hardened 17-4ph stainless steel. Ball bearings shall be made of hardened 440 stainless steel.

3.2 Top and bottom mounting plates shall be made of type 304 stainless steel and have an electro-polished finish.

4 Load Cell Specifications

4.1 All load cells shall meet or exceed the National Institute of Standards and Technology (NIST) Handbook 44 for Class III weighing devices and shall be certified by the National Type Evaluation Program (NTEP) for 5,000 division Class III accuracy.

4.2 All load cells shall be certified to meet or exceed Organisation de Metrologie Legale (OIML) C3 R60 3,000 division accuracy requirements.

4.3 Load cells shall have the following individual characteristics:

4.3.1	Rated Capacity (R.C.):	____________
4.3.2	Rated Output:	____________
4.3.3	Zero Balance:	____________
4.3.4	Combined Error Due To Non-Linearity & Hysteresis:	____________
4.3.5	Non-Repeatability:	____________
4.3.6	Temperature Compensation:	____________
4.3.7	Terminal Resistance	
	Input:	____________
	Signal:	____________
4.3.8	Excitation Voltage:	____________
4.3.9	Insulation Resistance:	____________
4.3.10	Maximum Loads	
	Safe Overload:	150% of R.C.
	Ultimate Overload:	300% of R.C.
	Safe Side Load:	100% of R.C.

4.4 Each load cell shall have a hermetically sealed strain gauge cavity.

4.5 Each load cell shall have a data plate affixed to the load cell which clearly shows:

- 4.5.1 Manufacturer
- 4.5.2 Capacity
- 4.5.3 Part Number
- 4.5.4 Serial Number
- 4.5.5 Class Number
- 4.5.6 NTEP Certificate of Conformance Number
- 4.5.7 Maximum Divisions (Nmax)
- 4.5.8 Load Cell Vmin

4.6 Load cells shall be mounted to the base plate with stainless steel socket head cap screws.

5 Junction Box Specifications

5.1 Junction box enclosure shall be constructed of type 304 stainless steel and shall be designed to NEMA 4X/IP65 standards.

5.2 The junction box enclosure shall have washdown duty connectors, one for each load cell cable, and one additional connector for the instrument cable. Multiple cables using single box connectors are not acceptable.

5.3 The junction box shall contain a printed circuit board for the purpose of individual load cell wiring termination, summing of the output signals from each load cell, trimming/balancing the load cell signals, and wiring the interface to the digital instrument.

5.4 The printed circuit board shall have individual connectors for each of the load cells, and the instrument interface cable. Each wire shall have a single terminal connection. Doubling up or ganging of wires to one terminal is not acceptable.

5.5 The summing printed circuit board shall have potentiometers, one per load cell for the electrical trimming/balancing of the load cell signals during calibration.

6 Warranty

6.1 The product shall be free from defects in workmanship and materials for a period of 1 year from date of original installation, or 18 months from the date of shipment to the original buyer, whichever occurs first. The manufacturer shall cover technician travel time and mileage costs for the first 30 days after installation, with on-site labor and replacement parts covered for the first 12 months after installation.

7 Acceptable Manufacturers

7.1 Scale system shall be METTLER TOLEDO Ultramount Weigh Modules with "ball-and-cup" suspension.

System Specifications			
Qty.*	**Load Cell Capacity (kg)**	**System Capacity (kg)**	**Cable Length (m)**
3	5	15	3
4	5	20	3
3	10	30	3
4	10	40	3
3	20	60	3
4	20	80	3
3	50	150	3
4	50	200	3
3	100	300	3
4	100	400	3

*System configurations of five or more modules are possible.

Table 14-33: Weigh Module System Specifications (Ultramount)

Load Cell Specifications	
Rated Capacity of Load Cell (kg)	5*, 10, 20, 50, 100
Rated Output	2.0 mV/V +1.0% or -0.1% (for 5 kg) 2.0 mV/V ±0.05% (for 10-100 kg)
Zero Balance	± 0.02 mV/V
Combined Error Due to Non-Linearity and Hysteresis	0.02% of R.C.
Non-Repeatability	0.01% of R.C.
Temperature Compensation	-10° to +40° C +14° to +104° F
Terminal Resistance	Input: 350Ω to 480Ω Signal: 356Ω ±0.12Ω
Excitation Voltage	18 VDC maximum
Insulation Resistance	> 1 GigaΩ @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

*5-kg load cell is NTEP Certified for 1,000d CIII, OIML Certified for 1,000d C3.

Table 14-34: Load Cell Specifications (Ultramount)

Value Line Weigh Modules

The portions of this specification that have been left blank (___________) should be filled with information about the specific application. Information for the blanks in Section 1.1 can be found in Table 14-35. Information for the blanks in Sections 4.2.1 to 4.2.9 can be found in Table 14-36.

1 General Provisions

1.1 Provide a complete system consisting of ______ (qty) ______ lb carbon steel weigh modules to convert a freestanding structure into a scale.

1.2 Each module shall include load cell, compression-mount receiver plate, and bottom mounting plate.

1.3 The system shall include a stainless steel NEMA 4X/IP65 summing junction box.

1.4 Each weigh module shall be completely factory assembled.

2 Mechanical Specifications

2.1 The suspension system shall be comprised of shock absorbing compression-mount receiver plates that are rigidly bolted to the load cells. Compression load receivers shall consist of steel inner plates covered by neoprene rubber.

2.2 Compression-mount receiver plates shall allow for minimal horizontal movement at each module.

2.3 Each module shall be equipped with an adjustable load cell overload stop bolt.

3 Material and Finish Specification

3.1 Load cells shall be made of hardened 17-4ph stainless steel.

3.2 The bottom mounting plates and all spacers shall be zinc-plated 1018 CR carbon steel.

4 Load Cell Specifications

4.1 All load cells shall meet or exceed the National Institute of Standards and Technology (NIST) Handbook 44 for Class III weighing devices and shall be certified by the National Type Evaluation Program (NTEP) for 5,000 division Class III accuracy.

4.2 Load cells shall have the following individual characteristics:

4.2.1	Rated Capacity (R.C.):	_____________
4.2.2	Rated Output:	_____________
4.2.3	Zero Balance:	_____________
4.2.4	Combined Error Due To Non-Linearity & Hysteresis:	_____________
4.2.5	Non-Repeatability:	_____________
4.2.6	Temperature Compensation:	_____________
4.2.7	Terminal Resistance	
	Input:	_____________
	Signal:	_____________
4.2.8	Excitation Voltage:	_____________
4.2.9	Insulation Resistance:	_____________
4.2.10	Maximum Loads	
	Safe Overload:	150% of R.C.
	Ultimate Overload:	300% of R.C.
	Safe Side Load:	100% of R.C.

4.3 Load cells shall be constructed of 17-4ph stainless steel and shall have an environmentally protected strain gauge cavity.

4.4 Each load cell shall have an integral conduit fitting on the cable entrance into the load cell for enhanced moisture protection.

4.5 Each load cell shall have a data plate affixed to the load cell which clearly shows:

4.5.1 Manufacturer
4.5.2 Capacity
4.5.3 Part Number
4.5.4 Serial Number
4.5.5 Class Number
4.5.6 NTEP Certificate of Conformance Number
4.5.7 Maximum Divisions (Nmax)
4.5.8 Load Cell Vmin

4.6 Load cells shall be mounted to the base plate with high strength GR.8 socket head cap screws minimum.

5 Junction Box Specifications

5.1 Junction box enclosure shall be constructed of type 304 stainless steel and shall be designed to NEMA 4X/IP65 standards.

5.2 The junction box enclosure shall have washdown duty connectors, one for each load cell cable, and one additional connector for the instrument cable. Multiple cables using single box connectors are not acceptable.

5.3 The junction box shall contain a printed circuit board for the purpose of individual load cell wiring termination, summing of the output signals from each load cell, trimming/balancing the load cell signals, and wiring the interface to the digital instrument.

5.4 The printed circuit board shall have individual connectors for each of the load cells, and the instrument interface cable. Each wire shall have a single terminal connection. Doubling up or ganging of wires to one terminal is not acceptable.

5.5 The summing printed circuit board shall have potentiometers, one per load cell for the electrical trimming/balancing of the load cell signals during calibration.

6 Warranty

6.1 The product shall be free from defects in workmanship and materials for a period of 1 year from date of original installation, or 18 months from the date of shipment to the original buyer, whichever occurs first. The manufacturer shall cover technician travel time and mileage costs for the first 30 days after installation, with on-site labor and replacement parts covered for the first 12 months after installation.

7 Acceptable Manufacturers

7.1 Scale system shall be METTLER TOLEDO VLM2 Weigh Modules.

NIST System Specifications				
Qty.*	Load Cell Capacity (lb)	System Capacity (lb)	Cable Length (ft)	Conduit Fitting
1	250	250	20	1/4-18 NPT
3	250	750	20	1/4-18 NPT
4	250	1,000	20	1/4-18 NPT
1	500	500	20	1/4-18 NPT
3	500	1,500	20	1/4-18 NPT
4	500	2,000	20	1/4-18 NPT
1	1,000	1,000	20	1/4-18 NPT
3	1,000	3,000	20	1/4-18 NPT
4	1,000	4,000	20	1/4-18 NPT
1	2,000	2,000	20	1/4-18 NPT
3	2,000	6,000	20	1/4-18 NPT
4	2,000	8,000	20	1/4-18 NPT
1	2,500	2,500	20	1/4-18 NPT
3	2,500	7,500	20	1/4-18 NPT
4	2,500	10,000	20	1/4-18 NPT

*System configurations of five or more modules are possible.

Table 14-35: NIST Weigh Module System Specifications (VLM2)

NIST Load Cell Specifications	
Rated Capacity of Load Cell (lb)	250*, 500, 1,000, 2,000, 2,500
Rated Output	3.0 ± 0.010 mV/V
Zero Balance	± 2% of R.C.
Combined Error Due to Non-Linearity and Hysteresis	0.03% of R.C.
Non-Repeatability	0.01% of R.C.
Temperature Compensation	-10° to +40° C +14° to +104° F
Terminal Resistance	Input: 350Ω Signal: 350Ω ±3Ω
Excitation Voltage	15 VDC maximum
Insulation Resistance	5 GigaΩ minimum @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

*250-lb load cell is not NTEP Certified.

Table 14-36: NIST Load Cell Specifications (VLM2)

Tension Weigh Modules

The portions of this specification that have been left blank (__________) should be filled with information about the specific application. Information for the blanks in Section 1.1 can be found in Table 14-37 for capacities in pounds (Table 14-38 for capacities in kilograms). Information for the blanks in Sections 4.3.1 to 4.3.9 can be found in Table 14-39.

1 General Provisions

1.1 Provide a complete system consisting of ______ (qty) ______ lb/kg tension weigh modules.

1.2 Each module shall include S-cell, clevis pins, clevis, jam nuts, rod ends, and hair-pin cotters.

1.3 The system shall include a stainless steel NEMA 4X/IP65 summing junction box.

1.4 Each weigh module shall be completely factory assembled.

2 Mechanical Specifications

2.1 The load cells shall be positioned around the vessel so that each support point carries an equal portion of the load.

2.2 Tension weigh module assemblies shall include a spherical rod end bearing/clevis attachment on both ends of the load cell to compensate for any misalignment of support rods.

2.3 Each tension weigh module in a system shall share an equal portion of the gross load. Space the modules accordingly.

2.4 Always use a secondary safety support system of chains or rods to prevent the vessel from falling in case of tension weigh module component failure.

3 Material and Finish Specification

3.1 Load cells shall be made of 17-4ph stainless steel.

3.2 Clevis, hitch pin, and rod end bearing shall be electroless nickel or zinc plated.

3.3 Pivoting ball in rod end shall be alloy steel, heat treated, and hard chrome plated.

4 Load Cell Specifications

4.1 All load cells shall meet or exceed the National Institute of Standards and Technology (NIST) Handbook 44 for Class III weighing devices and shall be certified by the National Type Evaluation Program (NTEP) for 3,000 division Class III accuracy.

4.2 OIML load cells can be offered as an option.

4.3 Load cells shall have the following individual characteristics:

4.3.1	Rated Capacity (R.C.):	__________
4.3.2	Rated Output:	__________
4.3.3	Zero Balance:	__________
4.3.4	Combined Error Due To Non-Linearity & Hysteresis:	__________
4.3.5	Non-Repeatability:	__________
4.3.6	Temperature Compensation:	__________
4.3.7	Terminal Resistance	
	Input:	__________
	Signal:	__________
4.3.8	Excitation Voltage:	__________
4.3.9	Insulation Resistance:	__________
4.3.10	Maximum Loads	
	Safe Overload:	150% of R.C.

Ultimate Overload:	300% of R.C.
Safe Side Load:	100% of R.C.

4.4 Load cells shall be constructed of 17-4ph stainless steel and shall have an environmentally protected gauge cavity.

4.5 Each load cell shall have a sealed cable fitting on the cable entrance into the load cell for enhanced moisture protection.

4.6 Each load cell shall have a data plate affixed to the load cell which clearly shows:

- 4.6.1 Manufacturer
- 4.6.2 Capacity
- 4.6.3 Part Number
- 4.6.4 Serial Number
- 4.6.5 Class Number
- 4.6.6 NTEP Certificate of Conformance Number
- 4.6.7 Maximum Divisions (Nmax)
- 4.6.8 Load Cell Vmin

5 Junction Box Specifications

5.1 Junction box enclosure shall be constructed of type 304 stainless steel and shall be designed to NEMA 4X/IP65 standards.

5.2 The junction box enclosure shall have washdown duty connectors, one for each load cell cable, and one additional connector for the instrument cable. Multiple cables using single box connectors are not acceptable.

5.3 The junction box shall contain a printed circuit board for the purpose of individual load cell wiring termination, summing of the output signals from each load cell, trimming/balancing the load cell signals, and wiring the interface to the digital instrument.

5.4 The printed circuit board shall have individual connectors for each of the load cells, and the instrument interface cable. Each wire shall have a single terminal connection. Doubling up or ganging of wires to one terminal is not acceptable.

5.5 The summing printed circuit board shall have potentiometers, one per load cell for the electrical trimming/balancing of the load cell signals during calibration.

6 Warranty

6.1 The product shall be free from defects in workmanship and materials for a period of 1 year from date of original installation, or 18 months from the date of shipment to the original buyer, whichever occurs first. Technician travel time and mileage costs shall be covered by the manufacturer for the first 30 days after installation, with on-site labor and replacement parts covered for the first 12 months after installation.

7 Acceptable Manufacturers

7.1 Scale system shall be METTLER TOLEDO 0978 Tension Weigh Modules.

NIST System Specifications				
Qty.*	Load Cell Capacity (lb)	System Capacity (lb)	Cable Length (ft)	Load Cell Material
1	50	50	25	17-4 ph Stainless Steel
3	50	150	25	17-4 ph Stainless Steel
4	50	200	25	17-4 ph Stainless Steel
1	100	100	25	17-4 ph Stainless Steel
3	100	300	25	17-4 ph Stainless Steel
4	100	400	25	17-4 ph Stainless Steel
1	200	200	25	17-4 ph Stainless Steel
3	200	600	25	17-4 ph Stainless Steel
4	200	800	25	17-4 ph Stainless Steel
1	300	300	25	17-4 ph Stainless Steel
3	300	900	25	17-4 ph Stainless Steel
4	300	1,200	25	17-4 ph Stainless Steel
1	500	500	25	17-4 ph Stainless Steel
3	500	1,500	25	17-4 ph Stainless Steel
4	500	2,000	25	17-4 ph Stainless Steel
1	1,000	1,000	25	17-4 ph Stainless Steel
3	1,000	3,000	25	17-4 ph Stainless Steel
4	1,000	4,000	25	17-4 ph Stainless Steel
1	2,000	2,000	25	17-4 ph Stainless Steel
3	2,000	6,000	25	17-4 ph Stainless Steel
4	2,000	8,000	25	17-4 ph Stainless Steel
1	3,000	3,000	25	17-4 ph Stainless Steel
3	3,000	9,000	25	17-4 ph Stainless Steel
4	3,000	12,000	25	17-4 ph Stainless Steel
1	5,000	5,000	25	17-4 ph Stainless Steel
3	5,000	15,000	25	17-4 ph Stainless Steel
4	5,000	20,000	25	17-4 ph Stainless Steel
1	10,000**	10,000	25	17-4 ph Stainless Steel
3	10,000**	30,000	25	17-4 ph Stainless Steel
4	10,000**	40,000	25	17-4 ph Stainless Steel

*System configurations of five or more modules are possible.
**Not NTEP Certified.

Table 14-37: NIST Weigh Module System Specifications (Tension Weigh Modules)

OIML System Specifications				
Qty.*	Load Cell Capacity (kg)	System Capacity (kg)	Cable Length (m)	Load Cell Material
1	25	25	7.62	17-4 ph Stainless Steel
3	25	75	7.62	17-4 ph Stainless Steel
4	25	100	7.62	17-4 ph Stainless Steel
1	50	50	7.62	17-4 ph Stainless Steel
3	50	150	7.62	17-4 ph Stainless Steel
4	50	200	7.62	17-4 ph Stainless Steel
1	100	100	7.62	17-4 ph Stainless Steel
3	100	300	7.62	17-4 ph Stainless Steel
4	100	400	7.62	17-4 ph Stainless Steel
1	200	200	7.62	17-4 ph Stainless Steel
3	200	600	7.62	17-4 ph Stainless Steel
4	200	800	7.62	17-4 ph Stainless Steel
1	500	500	7.62	17-4 ph Stainless Steel
3	500	1,500	7.62	17-4 ph Stainless Steel
4	500	2,000	7.62	17-4 ph Stainless Steel
1	1,000	1,000	7.62	17-4 ph Stainless Steel
3	1,000	3,000	7.62	17-4 ph Stainless Steel
4	1,000	4,000	7.62	17-4 ph Stainless Steel
1	2,000	2,000	7.62	17-4 ph Stainless Steel
3	2,000	6,000	7.62	17-4 ph Stainless Steel
4	2,000	8,000	7.62	17-4 ph Stainless Steel
1	5,000	5,000	7.62	17-4 ph Stainless Steel
3	5,000	15,000	7.62	17-4 ph Stainless Steel
4	5,000	20,000	7.62	17-4 ph Stainless Steel

*System configurations of five or more modules are possible.

Table 14-38: OIML Weigh Module System Specifications (Tension Weigh Modules)

Load Cell Specifications		
Rated Capacity of Load Cell	50, 100, 200, 300, 500, 1,000, 2,000, 3,000, 5,000, 10,000 (lb)	25, 75, 100, 200, 500, 1,000, 2,000, 5,000 (kg)
Rated Output	2.0 ± 0.2 mV/V	2.0 ± 0.2 mV/V
Zero Balance	± 1.0% of R.C.	± 1.0% of R.C.
Combined Error Due to Non-Linearity and Hysteresis	0.03% of R.C.	0.03% of R.C.
Non-Repeatability	0.01% of R.C.	0.01% of R.C.
Temperature Compensation	-10° to +40° C +14° to +104° F	-10° to +40° C +14° to +104° F
Terminal Resistance	Input: 350Ω Signal: 350Ω ±3Ω	Input: 350Ω Signal: 350Ω ±3Ω
Excitation Voltage	20 VDC maximum	20 VDC maximum
Insulation Resistance	5 GigaΩ minimum @ 50 VDC	5 GigaΩ minimum @ 50 VDC
Maximum Loads % of R.C.	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100	Safe Overload: 150 Ultimate Overload: 300 Safe Side Load: 100

Table 14-39: Load Cell Specifications (Tension Weigh Modules)

Appendix 12: Chemical Resistance Chart

The following chemical resistance chart is provided as a guide to help select materials for weigh module system components and hardware. The information is reprinted courtesy of Little Giant Pump Company.

These recommendations are based on information from material suppliers and careful examination of available published information and are believed to be accurate. However, since the resistance of metals, plastics, and elastomers can be affected by concentration, temperature, presence of other chemicals, and other factors, this information should be considered as a general guide rather than an unqualified guarantee. Ultimately, the customer must determine the suitability of the materials used in various environments.

All recommendations assume ambient temperatures unless otherwise noted. The ratings for these materials are based on the chemical resistance only. Added consideration must be given to material selection when the chemical is abrasive, viscous in nature, or has a Specific Gravity greater than 1.1.

Note: Ceramagnet "A" is generically known as barium ferrite.

RATINGS—CHEMICAL EFFECT
A—No effect—Excellent
B—Minor effect—Good
C—Moderate effect—Fair
D—Severe effect—Not Recommended

FOOTNOTES
1. PVC—Satisfactory to 72°F
2. Polypropylene—Satisfactory to 72°F
3. Polypropylene—Satisfactory to 120°F
4. Buna-N—Satisfactory for O-Rings
5. Polyacetal—Satisfactory to 72°F
6. Ceramag—Satisfactory to 72°F

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type 1)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Acetaldehyde[5]	A	A	A	-	B	A	A	D	-	-	C	-	D	D	A	-	A	A	D	C	B	A	A	A	-	D	B	B	D	B	C	A
Acetamide	-	B	A	-	-	-	-	-	-	-	C	-	-	-	-	-	B	-	-	-	-	-	-	A	-	A	A	-	A	A	D	A
Acetate Solv.[2]	A	B	A	B	B	-	-	A	C	B	A	-	B	D	A	-	-	A	-	B	D	-	A	A	-	D	D	-	D	-	-	A
Acetic Acid, Glacia[1]	-	B	A	A	B	A	A	C	C	D	A	-	C	B	A	C	D	D	D	B	B	A	A	A	-	D	D	B	C	B	C	B
Acetic Acid (20%)	-	B	A	-	-	A	A	-	C	-	-	A	B	-	A	A	-	D	-	-	A	A	-	A	-	A	C	-	C	-	-	B
Acetic Acid (80%)	-	B	A	-	-	A	A	-	C	-	-	A	D	-	A	B	-	D	-	-	B	-	-	A	-	A	C	-	D	-	-	B
Acetic Acid	-	B	A	B	B	A	A	C	C	D	C	B	A	B	A	A	D	D	C	B	A	A	A	A	-	C	C	-	C	B	C	A
Acetic Anhydride	B	A	A	B	B	A	A	C	D	B	D	D	D	D	A	D	D	D	D	A	A	A	A	A	-	D	A	C	B	B	C	A
Acetone[6]	A	A	A	B	A	A	A	A	A	A	A	D	D	D	A	D	B	A	D	C	B	A	A	A	A	D	D	B	C	A	D	B
Acetyl Chloride	-	C	A	-	-	-	-	D	-	-	-	-	-	-	A	-	-	-	-	-	-	A	-	-	-	A	-	-	-	-	A	A
Acetylene[2]	A	A	A	A	A	B	-	B	-	A	A	-	B	-	-	-	A	A	-	-	D	A	A	A	-	A	A	C	B	A	C	A
Acrylonitrile	A	A	C	-	B	B	B	A	-	C	-	-	-	-	-	-	B	-	D	-	B	A	A	A	-	C	D	-	D	D	-	A
Alcohols																																
Amyl	A	A	A	-	C	A	A	A	B	C	C	A	A	B	A	C	A	A	B	B	B	A	A	A	-	A	A	D	A	A	C	A
Benzyl	-	A	A	-	B	A	A	A	C	-	-	-	D	B	-	A	A	A	D	D	A	-	A	A	-	A	D	-	B	B	D	A
Butyl	A	A	A	-	B	B	A	B	C	C	C	A	A	B	A	A	A	A	-	B	B	A	A	A	-	A	A	D	A	A	A	A
Diacetone[2]	-	A	A	-	A	A	A	A	C	-	A	-	D	-	-	A	A	A	-	-	D	-	A	A	-	D	D	-	D	A	D	A
Ethyl	-	A	A	A	B	A	A	A	C	A	A	-	A	C	-	A	B	A	B	B	A	-	A	A	A	A	A	B	A	B	A	A

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type 1)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Hexyl	-	A	A	-	A	A	A	A	C	-	A	-	-	-	-	A	A	A	-	-	A	-	A	A	-	A	A	D	B	A	A	A
Isobutyl	-	A	A	-	B	A	A	A	C	-	A	-	-	-	-	A	A	A	B	-	A	-	A	A	-	A	C	B	A	A	A	A
Isopropyl	-	A	A	-	B	A	A	A	C	C	A	-	-	-	-	A	A	A	-	-	A	-	A	A	-	A	C	C	B	A	A	A
Methyl[6]	-	A	A	A	B	A	A	A	C	A	A	-	B	-	A	A	C	A	D	B	A	-	A	A	A	C	B	-	A	A	A	A
Octyl	-	A	A	-	A	A	A	A	C	-	A	-	-	-	-	A	A	A	-	-	-	-	A	A	-	A	B	-	B	A	C	A
Propyl	-	A	A	-	A	A	A	A	-	-	A	B	A	-	A	A	A	A	-	-	A	-	A	A	-	A	A	B	A	A	A	A
Aluminum Chloride (20%)	-	D	C	D	B	A	A	D	-	D	A	-	A	B	-	A	C	A	-	B	A	A	A	A	-	A	A	-	A	A	A	A
Aluminum Chloride	C	D	C	-	D	C	A	C	-	D	B	A	A	A	A	A	-	D	-	-	A	A	A	A	-	A	A	C	A	-	-	A
Aluminum Fluoride	-	D	C	D	-	D	B	-	-	-	A	A	A	-	A	A	C	D	-	B	A	-	A	-	-	A	A	C	A	-	C	A
Aluminum Hydroxide[6]	-	A	A	A	A	-	-	A	-	D	A	-	A	-	A	A	B	A	-	-	A	-	A	A	A	A	A	-	A	-	A	A
Alum Potassium Sulfate (Alum), (10%)	-	A	-	-	A	-	B	-	-	D	A	-	A	-	A	-	-	A	-	A	-	-	A	A	-	A	-	-	A	-	A	A
Alum Potassium Sulfate (Alum), (100%)	-	D	A	B	B	-	B	C	-	-	A	-	A	B	A	A	C	D	-	B	A	-	A	A	-	A	A	-	A	-	A	A
Aluminum Sulfate	-	C	C	A	A	A	A	C	C	D	A	A	A	B	A	A	C	A	-	B	A	A	A	A	-	A	A	-	A	A	A	A
Amines	A	A	A	-	A	B	A	B	-	A	B	-	C	A	A	B	D	A	-	-	-	-	A	A	-	D	D	C	B	B	C	A
Ammonia (10%)	-	-	A	-	-	A	A	-	-	-	-	D	A	-	A	A	-	A	-	-	A	A	-	A	-	A	D	-	A	-	-	B
Ammonia, Anhydrous	A	B	A	A	B	B	A	D	-	D	B	D	A	B	A	A	D	A	-	B	A	B	C	A	-	D	B	B	A	A	D	A
Ammonia, Liquids	-	A	A	A	D	-	B	D	-	A	A	-	A	B	A	A	D	-	-	D	A	-	A	A	-	D	B	B	A	A	D	A
Ammonia, Nitrate	-	A	A	A	C	-	-	D	-	-	A	-	B	B	-	A	C	-	-	-	A	-	A	A	-	-	A	-	C	-	-	A
Ammonium Bifluoride	-	C	A	-	D	-	B	-	-	-	-	-	A	-	-	A	D	-	-	-	A	-	-	A	-	A	A	-	A	-	-	A
Ammonium Carbonate	B	A	A	A	C	A	B	B	-	C	B	-	A	B	A	A	D	A	-	-	A	-	A	A	-	B	D	C	A	A	-	A
Ammonium Casenite	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	A	D	-	-	-	-	-	-	-	-	-	-	-	A	-	-	A
Ammonium Chloride	C	A	C	A	C	D	A	D	C	D	D	A	A	B	A	A	B	A	-	B	A	A	A	A	-	A	A	C	A	A	A	A
Ammonium Hydroxide	A	A	A	A	C	A	A	D	D	A	C	-	A	B	A	A	D	A	B	B	A	A	A	A	-	B	B	B	A	A	C	A
Ammonium Nitrate	A	A	A	A	B	A	A	D	D	A	D	-	A	B	A	A	C	D	-	B	A	A	A	A	-	D	A	C	A	A	A	A
Ammonium Oxalate	-	A	A	A	-	-	A	-	-	-	A	-	-	-	-	-	B	-	-	-	-	-	A	-	-	-	A	-	A	-	-	A
Ammonium Persulfate	-	A	A	A	C	C	A	A	-	D	A	D	A	-	A	A	D	D	-	-	A	-	A	A	-	C	A	-	A	A	A	A
Ammonium Phosphate, Dibasic	B	A	A	A	B	A	A	C	-	-	D	-	A	-	A	A	B	A	-	B	A	-	A	A	-	A	A	B	A	A	A	A
Ammonium Phosphate, Monobasic	-	A	A	A	B	A	A	D	-	-	A	-	A	A	A	A	B	A	-	B	A	-	A	A	-	A	A	B	A	A	A	A
Ammonium Phosphate, Tribasic	B	A	A	A	B	A	A	C	-	C	D	-	A	-	A	A	B	A	-	B	A	-	A	A	-	A	A	B	A	A	A	A
Ammonium Sulfate	C	D	B	A	B	A	A	B	C	C	C	A	A	D	A	A	B	D	-	B	A	A	A	A	-	D	A	B	A	A	A	A
Ammonium Thio-Sulfate	-	-	A	-	-	A	-	-	-	D	A	-	-	-	-	-	B	-	-	-	-	-	A	A	-	-	A	-	A	-	-	A
Amyl-Acetate	B	A	A	C	B	A	A	C	-	-	C	C	D	D	A	D	A	B	-	D	D	A	A	A	-	D	D	D	D	A	D	A
Amyl Alcohol	-	A	A	-	B	A	A	A	-	-	A	A	A	B	A	C	A	A	-	B	A	-	A	A	-	B	B	D	A	A	C	A
Amyl Chloride	-	C	B	-	D	-	A	A	-	-	A	A	D	C	A	D	A	C	-	D	D	-	A	A	-	A	D	-	D	D	D	A
Aniline	B	A	A	A	C	A	B	C	-	-	C	C	D	D	A	D	D	C	D	C	B	A	A	A	-	C	D	C	D	B	D	A
Anti-Freeze	-	A	A	-	A	-	A	B	B	B	C	-	A	B	A	A	A	A	B	B	A	A	A	A	A	A	A	C	A	A	A	A
Antimony Trichloride	-	D	D	-	D	C	A	-	-	-	-	-	A	A	A	-	-	D	-	A	-	-	-	A	-	A	-	-	C	-	A	A
Aqua Regia (80% HCl, 20% HNO)	-	D	D	-	D	A	D	D	-	-	-	C	D	D	A	D	D	D	-	D	C	-	-	D	-	C	D	C	D	D	D	D
Arochlor 1248	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	D	-	-	-	-	-	-	A	-	-	A	D	-	D	B	D	A
Aromatic Hydrocarbons	-	-	A	-	A	-	-	A	-	A	A	-	D	-	-	D	A	-	-	C	-	-	A	-	-	A	D	-	D	D	D	A
Arsenic Acid	B	A	A	-	D	-	-	D	B	D	D	A	A	B	A	A	D	A	-	B	A	-	A	A	-	A	A	-	A	-	C	A
Asphalt	-	B	A	-	C	-	-	A	-	C	-	-	A	-	-	-	A	A	-	-	A	A	-	A	A	A	B	C	B	D	D	A
Barium Carbonate	B	A	A	A	B	A	A	B	-	B	B	-	A	A	A	A	A	A	-	B	A	-	A	A	A	A	A	-	A	-	A	A
Barium Chloride	C	D	A	A	D	A	A	B	-	-	C	A	A	B	A	A	A	B	-	B	A	A	A	A	-	A	A	B	A	A	A	A
Barium Cyanide	-	-	A	-	-	-	-	C	-	-	A	-	-	-	-	-	B	-	-	B	-	-	A	-	-	A	C	-	A	A	-	A
Barium Hydroxide	B	C	A	A	D	B	B	B	-	C	C	A	A	-	A	A	D	A	-	B	A	A	A	A	A	A	A	C	A	A	A	A
Barium Nitrate	-	A	A	-	-	A	-	D	-	A	A	-	B	-	-	A	A	-	-	-	-	-	A	A	-	A	A	-	A	A	-	B
Barium Sulfate	B	A	A	A	D	A	A	C	-	C	C	A	A	-	A	A	A	A	-	B	A	A	A	B	-	A	A	D	A	A	-	B

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type I)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Barium Sulfide	B	A	A	-	D	B	-	C	-	C	C	-	A	A	A	A	A	A	-	B	A	-	A	A	-	A	A	C	A	A	A	A
Beer[2]	A	A	A	-	A	A	A	A	B	D	D	A	A	-	A	A	B	D	B	B	D	-	A	A	-	A	D	C	A	A	A	A
Beet Sugar Liquids	A	A	A	-	A	-	-	A	B	A	-	-	A	-	A	A	B	A	B	-	A	-	A	A	-	A	A	-	B	A	A	A
Benzaldehyde[3]	A	A	A	-	B	A	A	A	-	B	A	C	D	D	A	D	A	C	D	D	D	A	A	A	-	D	D	B	D	A	D	A
Benzene[2]	B	A	A	A	B	A	B	B	A	B	C	B	D	C	A	D	A	A	D	D	D	A	A	A	A	A	D	-	D	D	D	A
Benzoic Acid[2]	B	A	A	A	B	A	A	B	-	D	-	A	A	B	A	A	B	D	-	B	D	-	A	B	-	A	D	-	D	D	D	A
Benzol	-	A	A	-	B	A	A	B	A	-	-	-	D	-	A	D	A	A	-	-	A	-	A	A	A	D	D	-	D	-	-	A
Borax (Sodium Borate)	-	A	A	A	C	B	A	A	B	A	C	A	A	A	A	A	A	A	-	B	A	A	A	A	A	A	B	C	A	A	C	A
Boric Acid	B	A	A	A	B	A	A	B	C	D	-	A	A	B	A	A	A	A	-	B	A	-	A	A	A	A	A	-	A	A	A	A
Brewery Slop	-	-	A	-	-	-	-	A	-	A	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	A	A	-	A	-	-	A
Bromine[2] (Wet)	D	D	D	D	D	A	A	C	-	D	D	A	B	B	A	D	D	D	D	D	D	D	D	A	D	A	D	D	D	D	D	C
Butadiene	A	A	A	-	A	-	-	C	A	C	C	A	A	-	A	-	A	A	-	-	-	B	A	A	-	A	A	-	B	A	-	A
Butane[2] [1]	A	A	A	-	A	-	-	A	A	C	C	A	A	C	A	D	A	A	B	C	D	A	A	A	-	A	A	D	B	D	D	A
Butanol	-	A	A	-	A	-	A	A	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butter	-	B	A	-	A	-	-	D	-	D	-	-	-	B	-	B	A	-	B	-	-	-	A	A	-	A	A	-	B	A	D	A
Buttermilk	A	A	A	A	A	-	-	D	-	D	-	-	-	B	A	A	A	A	B	-	-	-	A	A	-	A	A	-	A	-	D	A
Butylene	A	B	A	-	A	-	-	A	A	A	A	-	B	-	A	-	A	-	-	-	-	A	A	A	-	A	B	-	-	D	D	A
Butyl Acetate[1]	-	-	C	-	A	-	A	A	-	-	A	C	D	D	A	D	A	-	-	C	D	A	A	A	-	D	B	D	D	B	D	A
Butyric Acid[1]	B	B	A	A	B	A	A	C	-	D	-	A	B	-	A	A	C	D	D	-	A	-	A	D	-	D	D	-	D	B	-	A
Calcium Bisulfate	C	D	A	-	D	-	-	D	D	D	-	-	A	A	A	-	-	A	-	-	-	-	-	-	-	A	A	C	C	-	A	A
Calcium Bisulfide	-	-	B	-	C	A	A	C	-	-	-	-	A	-	A	A	D	A	-	B	A	-	A	A	-	A	A	-	A	D	-	A
Calcium Bisulfite	-	B	A	-	C	A	A	C	-	-	-	A	A	-	A	A	-	A	-	-	A	-	-	A	-	A	A	-	A	-	A	-
Calcium Carbonate	B	A	A	A	C	A	A	C	-	D	-	-	A	A	A	A	A	A	-	B	A	-	A	A	-	A	A	-	A	-	A	A
Calcium Chlorate	-	B	A	-	-	B	B	C	-	-	-	-	A	A	A	-	-	A	-	A	-	-	A	-	-	A	-	-	A	-	A	A
Calcium Chloride	C	A	D	C	C	A	A	B	-	C	-	A	A	A	A	A	D	A	B	B	A	A	A	A	B	A	A	B	D	A	A	A
Calcium Hydroxide	B	A	A	-	C	A	A	B	-	-	-	-	A	A	A	A	B	A	-	B	A	-	A	A	A	A	A	C	A	A	A	A
Calcium Hypochlorite	D	D	C	C	C	A	B	D	-	D	-	A	D	-	A	A	D	D	-	B	A	-	A	A	-	A	B	C	D	A	C	A
Calcium Sulfate	B	A	A	A	B	A	B	B	-	-	-	A	A	A	A	A	A	A	C	B	A	A	A	A	-	A	A	-	D	-	C	A
Calgon	-	A	A	-	-	-	-	C	-	D	-	-	-	-	-	A	B	-	-	-	A	-	A	A	-	A	A	-	A	-	-	A
Cane Juice[2]	-	A	A	-	B	-	-	B	C	A	-	-	A	-	-	-	A	A	-	-	D	-	A	A	-	-	A	-	A	-	A	A
Carbolic Acid (See Phenol)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon Bisulfide[2]	B	A	A	A	A	-	-	C	-	B	-	-	D	D	-	-	A	A	-	-	D	-	A	A	A	A	D	-	D	D	D	A
Carbon Dioxide (Wet)	-	A	A	-	C	-	A	C	C	C	-	-	-	-	A	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-	-	-
Carbon Disulfide[2]	-	B	A	-	C	-	-	C	C	B	C	-	D	C	A	D	A	A	-	D	D	A	A	B	-	A	D	-	D	D	D	A
Carbon Monoxide	-	A	A	-	A	-	-	-	-	-	-	-	A	-	-	B	A	A	-	B	A	-	A	A	-	A	A	B	B	A	C	A
Carbon Tetrachloride[2] [1]	B	B	B	A	C	A	A	C	A	C	D	A	C	C	A	D	A	A	D	D	D	C	A	A	A	A	C	C	D	-	D	C
Carbonated Water	B	A	A	A	A	-	-	B	-	D	-	-	A	-	-	A	A	A	-	-	A	-	A	A	-	A	A	-	A	A	-	A
Carbonic Acid	B	A	B	A	A	-	A	B	-	D	-	A	A	-	A	A	A	A	-	B	A	-	A	A	-	A	B	B	A	A	A	A
Catsup	-	A	A	A	D	-	-	C	-	D	-	-	A	-	-	A	B	A	B	-	A	-	A	A	-	A	A	-	C	-	-	A
Chloracetic Acid[2]	D	D	D	D	C	A	A	D	-	D	-	D	A	D	A	-	D	D	-	D	D	-	A	A	-	D	D	-	D	B	D	B
Chloric Acid	-	D	D	-	-	-	-	-	-	-	-	-	D	-	A	-	-	-	-	-	-	-	-	-	-	-	D	-	D	-	-	D
Chlorinated Glue	-	A	A	-	D	-	-	C	-	D	-	-	-	-	-	C	-	C	D	-	-	-	-	A	-	A	C	-	D	B	D	A
Chlorine, Anhydrous Liquid	-	D	D	D	D	D	A	D	-	C	-	-	D	B	A	A	D	D	-	D	D	C	A	D	-	A	D	-	D	B	D	B
Chlorine (Dry)	B	A	A	-	D	D	A	A	B	A	-	-	-	-	A	-	-	-	-	-	-	C	A	A	-	D	-	-	D	-	D	D
Chlorine Water	D	-	D	-	D	A	B	D	D	D	-	A	A	-	A	C	-	D	-	-	D	C	C	A	-	A	D	C	D	-	-	-
Chlorobenzene (Mono)	A	A	A	-	B	-	A	B	-	B	C	A	D	D	A	D	A	A	D	D	D	A	A	A	-	A	D	-	D	D	D	A
Chloroform	A	A	A	A	D	A	A	B	-	D	C	C	D	C	A	D	A	C	D	D	D	C	A	A	A	A	D	D	D	D	D	A
Chlorosulfonic Acid[1]	D	D	-	D	D	A	B	D	-	-	D	D	C	C	A	D	D	D	-	D	D	D	-	C	-	D	D	D	D	D	D	C

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type 1)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Chlorox (Bleach)	-	A	A	-	C	-	A	A	-	D	C	-	A	B	A	A	D	D	B	-	D	C	A	A	-	A	C	-	B	B	D	A
Chocolate Syrup	-	A	A	-	A	-	-	-	-	D	-	-	-	-	-	A	A	A	-	-	A	-	-	A	-	A	A	-	A	-	D	A
Chromic Acid (5%)	-	A	A	B	C	A	A	D	D	D	-	-	A	B	-	C	D	D	B	B	A	A	D	C	-	A	D	C	D	A	B	B
Chromic Acid (10%)	-	B	-	-	-	A	A	-	D	-	-	A	A	-	A	A	-	D	-	-	A	-	-	A	-	A	D	-	D	-	-	C
Chromic Acid (30%)	-	B	-	-	-	A	A	-	D	-	-	B	A	-	A	D	-	D	-	-	A	-	-	A	-	A	D	-	D	-	-	D
Chromic Acid (50%)	C	B	B	-	C	A	A	D	D	D	-	C	B	B	A	D	D	D	C	C	B	B	D	A	-	A	D	-	D	A	D	C
Cider	-	A	A	A	B	-	-	A	-	D	-	-	A	-	-	A	B	-	-	B	-	-	A	A	-	A	A	-	A	-	-	A
Citric Acid	-	A	A	A	C	A	A	D	C	D	-	A	A	-	A	A	B	C	C	B	B	-	A	A	B	A	D	C	A	A	A	A
Citric Oils	-	A	A	-	C	-	-	B	-	-	-	-	-	-	-	A	B	-	-	-	A	-	A	A	-	A	A	C	D	-	-	A
Coffee	A	A	A	A	A	-	-	B	-	C	-	-	-	-	A	A	A	A	-	-	A	-	A	A	-	A	A	-	A	-	A	A
Copper Chloride	C	D	D	B	D	A	A	D	-	D	-	A	A	B	A	A	B	D	-	B	A	A	-	A	-	A	A	-	A	A	A	A
Copper Cyanide	-	A	A	A	D	A	A	C	-	D	-	A	A	-	A	A	B	A	-	B	A	A	A	A	-	B	B	-	A	A	A	C
Copper Fluoborate	-	D	D	-	D	-	B	D	-	D	-	-	A	-	A	-	B	-	-	A	-	-	A	-	-	A	B	-	A	-	A	A
Copper Nitrate	B	A	A	B	D	A	A	D	-	-	-	A	A	-	A	A	B	D	-	B	A	-	A	A	-	A	A	-	A	-	-	A
Copper Sulfate (5% Solution)	-	A	A	A	D	A	A	D	D	D	-	-	A	-	A	A	B	D	-	B	A	A	A	A	-	A	A	C	A	-	C	A
Copper Sulfate	B	B	-	-	-	A	A	C	D	-	-	A	A	-	A	A	-	C	-	-	A	-	-	A	-	B	B	-	A	A	-	A
Cream	-	A	A	-	A	-	-	C	-	D	-	-	-	-	-	A	A	A	-	-	A	-	A	A	-	A	A	-	C	-	-	A
Cresols[2]	-	A	A	-	B	-	-	D	C	-	-	-	D	D	-	-	D	-	D	D	C	A	A	A	-	D	D	D	D	D	D	A
Cresylic Acid	B	A	A	-	C	A	B	C	-	-	-	B	B	D	A	-	D	D	-	C	-	-	A	A	-	A	D	-	D	D	D	A
Cyclohexane	-	A	-	-	A	A	-	A	-	-	A	-	-	D	-	D	A	-	-	-	D	A	A	A	-	A	A	D	D	D	D	A
Cyanic Acid	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	C	-	D	-	-	A
Detergents	-	A	A	-	A	-	-	A	-	-	A	-	A	-	-	A	B	A	B	B	A	A	A	A	-	A	A	-	B	A	C	A
Dichlorethane	-	A	A	-	-	-	A	-	-	-	-	-	D	D	A	-	-	A	-	D	-	-	-	-	-	B	-	-	D	-	D	A
Diesel Fuel	A	A	A	-	A	-	-	A	-	A	A	-	-	-	-	D	A	-	-	-	D	A	A	A	-	A	A	-	D	D	D	A
Diethylamine	A	A	-	-	A	-	-	A	-	-	-	-	D	-	A	B	D	-	-	-	C	-	A	A	-	D	B	-	B	B	C	A
Diethylene Glycol	-	A	-	-	-	-	-	A	-	-	-	-	-	-	-	A	A	A	B	B	-	-	A	A	-	A	A	C	A	A	A	A
Diphenyl Oxide	-	A	-	-	-	-	-	A	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	A	D	-	D	D	D	A
Dyes	-	A	A	-	B	-	-	C	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-	-	-	A	-	-	C	-	-	A
Epsom Salts (Magnesium Sulfate)	B	A	A	A	A	A	B	B	-	-	-	-	A	-	-	A	A	-	-	-	A	-	A	A	-	A	A	-	A	-	C	A
Ethane	A	A	-	-	A	-	-	A	-	-	-	-	-	-	-	D	A	-	-	-	-	-	A	A	-	A	A	-	B	D	D	A
Ethanolamine	-	A	A	-	-	-	-	-	-	-	C	-	-	-	-	-	D	-	-	-	-	A	A	A	-	D	B	C	B	-	C	A
Ether[3]	A	A	A	A	A	-	B	B	A	-	B	-	D	C	-	D	A	C	-	-	-	A	A	A	A	C	D	-	D	C	D	A
Ethyl Acetate[2]	-	A	A	-	B	-	B	B	-	-	C	D	D	D	A	D	A	A	D	C	C	A	A	A	-	D	D	C	D	B	D	A
Ethyl Chloride	-	A	A	A	B	A	B	B	-	C	D	A	D	D	A	D	A	A	-	D	D	A	A	A	-	A	D	D	C	A	A	A
Ethyl Sulfate	-	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B	-	-	-	-	-	A	A	-	A	A	-	-	-	-	A
Ethylene Chloride[2]	-	A	A	-	C	B	B	A	-	C	C	-	D	-	A	D	A	-	D	-	D	A	A	A	-	A	D	D	D	C	D	A
Ethylene Dichloride	-	A	A	-	D	A	B	C	-	-	C	-	D	D	A	D	A	A	-	D	A	A	C	A	-	A	D	D	D	C	D	A
Ethylene Glycol[4]	-	A	A	-	A	-	A	B	B	B	C	A	A	B	A	A	A	A	B	B	A	A	A	A	A	A	A	C	A	A	A	A
Ethylene Oxide	-	-	A	-	A	-	-	A	-	-	-	-	D	-	A	A	A	A	-	-	-	-	A	A	-	D	D	D	D	C	D	A
Fatty Acids	-	A	A	-	B	A	A	C	-	D	-	A	A	B	A	B	A	A	-	B	A	-	A	A	-	A	C	C	B	C	C	A
Ferric Chloride	-	D	D	D	D	A	B	D	D	D	-	A	A	B	A	A	B	D	-	B	A	A	A	A	-	A	D	C	B	A	A	A
Ferric Nitrate	-	A	A	A	D	A	A	D	-	-	-	A	A	-	A	A	B	D	-	B	A	A	A	A	-	A	A	D	A	A	A	A
Ferric Sulfate	-	A	C	A	D	A	A	D	D	D	-	A	A	B	A	A	B	A	C	-	A	A	C	A	-	A	B	C	A	-	A	A
Ferrous Chloride	-	D	D	-	D	A	B	C	-	D	-	A	A	B	A	A	B	D	-	B	A	A	A	A	-	A	B	C	A	-	A	A
Ferrous Sulfate	B	A	C	-	D	A	B	C	-	D	D	A	A	B	A	A	B	D	-	B	A	A	A	A	-	A	B	-	A	-	A	A
Fluoboric Acid	-	D	B	-	-	D	A	-	-	D	-	A	A	B	A	B	B	C	-	B	A	-	A	D	-	A	B	-	A	-	-	A
Fluorine	D	D	D	-	D	D	A	D	-	D	D	-	C	-	C	-	-	D	-	C	-	-	D	-	-	-	-	-	-	-	-	D
Fluosilicic Acid	-	-	B	-	D	D	B	-	-	D	-	A	A	B	A	A	B	D	-	B	A	-	A	D	-	B	A	-	A	-	-	C

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type I)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Formaldehyde (40%)	-	-	A	-	-	A	A	-	-	-	-	B	B	-	A	A	-	D	-	-	A	A	-	A	-	D	B	B	A	-	-	A
Formaldehyde	A	A	A	-	A	A	B	A	B	D	A	-	A	B	A	D	A	A	-	B	A	A	A	A	-	D	C	B	D	B	C	A
Formic Acid[6]	C	A	B	B	D	C	A	C	C	D	D	A	D	B	A	A	D	D	-	B	A	A	A	A	B	B	D	C	D	A	C	B
Freon 11[1]	A	-	A	-	B	-	-	B	-	C	B	-	B	D	A	D	A	A	D	C	-	A	A	A	A	B	C	D	D	D	D	A
Freon 12 (Wet)[2]	-	-	D	-	B	-	-	B	-	-	-	-	B	D	A	D	A	A	B	C	A	A	A	A	A	A	A	D	B	B	D	A
Freon 22	-	-	A	-	B	-	-	B	-	-	-	-	D	D	-	B	A	A	-	-	-	A	A	A	A	D	D	D	A	A	A	A
Freon 113	-	-	A	-	B	-	-	B	-	-	-	-	C	D	-	-	A	A	-	-	-	A	A	A	A	C	A	D	A	-	D	A
Freon T.F.[4]	-	-	A	-	B	-	-	B	-	-	-	-	B	D	-	D	A	A	-	-	D	A	A	A	A	B	A	D	A	D	D	A
Fruit Juice	A	A	A	A	B	-	-	B	-	D	D	-	A	-	D	A	B	A	-	B	A	-	A	A	A	A	A	-	A	-	-	A
Fuel Oils	A	A	A	-	A	A	A	B	-	C	B	A	A	-	A	A	A	A	-	D	B	A	A	A	-	A	A	C	B	D	D	A
Furan Resin	-	A	A	-	A	-	-	A	-	A	A	-	-	-	A	-	A	-	-	-	-	A	-	A	-	A	D	-	D	-	D	A
Furfural[1]	A	A	A	-	A	-	B	A	-	-	A	D	D	-	A	D	B	A	D	D	D	A	A	A	-	D	D	D	D	B	D	A
Gallic Acid	B	A	A	-	A	-	A	A	-	D	D	-	A	A	A	-	-	A	-	-	-	-	-	-	-	B	A	-	-	-	-	-
Gasoline[1] [4]	A	A	A	A	A	D	A	A	-	A	A	A	C	-	A	D	A	A	D	D	C	A	A	A	A	A	A	D	D	C	D	A
Gelatin	A	A	A	A	A	-	A	A	C	D	D	-	A	-	A	A	A	A	-	-	A	-	A	A	-	A	A	-	A	A	A	A
Glucose	A	-	A	-	A	-	-	A	A	B	B	-	A	B	A	B	A	A	B	B	A	-	A	A	-	A	A	B	A	A	A	A
Glue P.V.A.[1]	B	B	A	-	B	A	-	A	-	-	A	-	A	B	A	-	A	A	-	-	-	-	A	A	-	A	A	-	A	-	-	A
Glycerine	A	A	A	A	A	A	A	A	B	B	B	A	A	B	A	A	A	A	C	-	A	-	A	A	-	A	A	B	A	A	A	A
Glycolic Acid	-	-	-	-	-	-	A	-	-	-	-	-	-	A	-	A	C	-	-	B	A	A	A	-	-	A	A	-	A	-	-	A
Gold Monocyanide	-	-	A	-	-	-	-	A	-	D	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	A	A	-	A	-	-	A
Grape Juice	-	A	A	-	B	-	-	B	-	D	-	-	A	-	-	A	B	-	B	B	-	-	A	A	-	A	A	-	A	-	-	A
Grease[4]	A	A	A	-	A	-	-	B	-	A	A	-	-	-	A	-	A	A	-	-	-	-	A	A	-	A	A	-	D	-	-	A
Heptane[1]	A	-	A	-	A	-	A	A	-	-	B	A	A	-	A	D	A	A	C	D	D	A	A	A	-	A	A	-	B	D	-	A
Hexane[1]	A	A	A	-	A	-	A	B	-	-	B	A	C	-	A	D	A	A	D	-	C	A	A	A	-	A	A	B	B	D	D	A
Honey	-	A	A	-	A	-	-	A	-	A	-	-	A	-	-	A	A	A	B	-	A	-	A	A	-	A	A	-	A	A	-	A
Hydraulic Oils (Petroleum)[1]	A	A	A	-	A	-	-	B	-	A	A	-	-	-	A	-	A	A	-	-	D	-	A	A	-	A	A	-	B	D	D	A
Hydraulic Oils (Synthetic)[1]	-	A	A	-	A	-	-	A	-	A	-	-	-	-	-	-	A	A	-	-	D	-	A	A	-	A	C	D	-	-	-	A
Hydrazine	-	A	A	-	-	-	-	-	-	C	-	-	-	-	-	-	D	-	-	-	-	-	A	-	-	A	B	D	B	A	C	A
Hydrobromic Acid (20%)	-	-	D	-	-	A	A	-	-	-	-	A	A	-	A	A	-	D	-	-	A	-	-	B	-	A	D	-	C	-	-	B
Hydrobromic Acid[4]	D	D	D	D	D	A	A	D	-	D	D	A	A	B	A	C	D	D	-	B	B	-	A	A	-	A	D	D	D	A	A	A
Hydrochloric Acid (Dry gas)	D	C	A	-	D	-	A	-	-	-	D	-	A	-	A	-	-	-	-	-	-	-	A	-	-	-	-	-	-	A	-	A
Hydrochloric Acid (20%)[4]	-	D	D	D	D	C	B	D	-	D	-	A	A	B	A	A	D	D	B	A	A	D	A	A	D	A	C	-	C	A	C	A
Hydrochloric Acid (37%)[4]	-	D	D	D	D	C	B	D	-	D	-	A	A	B	A	A	D	D	C	A	A	D	A	C	D	A	C	C	C	C	D	A
Hydrochloric Acid (100%)	-	D	D	-	D	D	C	D	-	D	-	-	A	A	A	-	-	D	-	A	-	-	A	C	-	C	D	-	C	-	A	A
Hydrocyanic Acid	A	A	A	C	A	A	A	D	D	-	C	-	A	B	A	A	B	A	-	B	A	-	A	A	-	A	C	-	B	-	A	A
Hydrocyanic Acid (Gas 10%)	-	D	D	-	-	-	-	-	-	-	-	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	C	A	C	A
Hydrofluoric Acid (20%)[1]	-	D	D	D	D	D	B	D	-	D	-	-	D	B	A	A	D	D	-	C	A	C	B	C	D	A	D	-	C	A	C	B
Hydrofluoric Acid (75%)[1] [2]	-	C	D	-	D	D	C	D	-	D	-	A	C	B	A	D	D	D	-	C	B	C	D	D	D	A	D	D	D	C	C	C
Hydrofluoric Acid (100%)	D	D	D	-	D	D	B	D	-	D	D	-	C	D	A	-	-	-	-	D	-	C	D	D	-	-	D	-	D	-	D	A
Hydrofluosilicic Acid (20%)	-	D	D	-	D	D	B	A	-	D	-	-	D	-	A	B	D	D	-	-	A	-	A	D	-	A	B	-	B	A	A	C
Hydrofluosilicic Acid	-	D	D	-	C	-	C	D	-	-	-	-	-	C	A	-	-	-	-	-	-	-	A	-	-	-	-	D	A	-	-	-
Hydrogen Gas	A	A	A	-	A	-	-	A	-	B	B	A	A	-	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A
Hydrogen Peroxide (10%)	-	C	C	-	A	C	A	D	D	D	-	-	A	A	A	-	-	D	-	A	-	B	A	A	-	-	A	-	D	-	C	D
Hydrogen Peroxide (30%)	-	-	B	-	-	B	A	-	D	-	-	-	A	-	A	-	-	D	-	-	A	C	-	-	-	A	D	-	C	-	-	B
Hydrogen Peroxide	-	A	B	A	A	B	A	D	D	D	D	C	A	C	A	B	D	D	-	B	A	C	-	A	A	A	D	C	D	C	C	A
Hydrogen Sulfide, Aqueous Solution	-	D	A	C	C	A	A	D	C	D	-	A	A	B	A	A	D	D	-	B	A	A	A	A	A	D	C	-	B	A	D	A
Hydrogen Sulfide (Dry)	A	C	A	-	D	-	A	D	C	B	B	-	A	-	A	-	-	D	-	-	-	A	-	A	-	D	-	-	-	-	A	A
Hydroxyacetic Acid (70%)	-	-	-	-	D	B	-	-	-	-	-	-	A	-	-	-	D	-	-	-	-	-	A	A	-	A	A	-	A	A	-	A

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type 1)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Ink	A	A	A	-	C	-	-	C	-	D	D	-	-	-	-	B	A	A	-	B	-	-	A	A	A	A	A	-	A	-	-	A
Iodine	-	D	D	D	D	A	B	D	-	D	-	-	D	B	A	A	C	D	D	D	D	-	D	A	-	A	B	-	D	B	D	A
Iodine (In Alcohol)	-	-	B	-	-	D	A	-	-	-	-	-	D	-	A	C	-	D	-	-	B	-	-	A	-	A	D	-	D	-	-	-
Iodoform	B	C	A	-	A	-	-	C	-	C	B	-	-	-	A	-	-	A	-	-	-	-	-	-	-	A	-	-	-	-	-	-
Isotane[2]	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	D	A	-	-	-	D	-	-	A	-	A	A	-	-	-	D	A
Isopropyl Acetate	-	-	B	-	C	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	D	D	-	D	B	D	A
Isopropyl Ether[2]	A	-	A	-	A	-	-	A	-	-	A	-	-	-	A	D	A	-	-	-	D	-	A	A	-	D	B	-	D	D	D	-
Jet Fuel (JP#, JP4, JP5)	A	A	A	-	A	-	-	A	-	A	A	A	A	-	A	D	A	A	-	-	D	A	A	A	-	A	A	D	D	D	D	A
Kerosene[2]	A	A	A	A	A	A	A	A	A	A	B	A	A	D	A	D	A	A	B	D	D	A	A	A	A	A	A	D	D	A	D	A
Ketones	A	A	A	-	B	A	A	A	-	A	A	D	D	D	A	D	B	A	-	D	D	A	C	A	-	D	D	-	D	D	C	C
Lacquers	A	A	A	-	A	-	-	A	C	C	C	-	-	D	-	C	A	A	-	-	A	-	A	A	-	D	D	-	D	-	D	A
Lacquer Thinners	-	-	A	-	-	A	A	-	C	-	-	-	C	-	A	D	-	A	-	-	B	-	-	A	-	-	D	-	D	A	-	-
Lactic Acid	A	A	B	C	C	A	A	D	-	D	D	C	A	B	A	A	B	C	-	B	A	A	A	A	-	B	B	-	A	B	A	A
Lard	B	A	A	A	A	-	-	A	-	A	C	-	A	-	-	-	A	A	C	-	A	-	A	A	-	A	A	C	B	-	D	A
Latex	-	A	A	-	A	-	-	A	-	-	-	-	-	-	-	A	A	A	-	B	-	-	-	A	-	A	A	-	C	A	-	A
Lead Acetate	B	A	A	-	D	A	A	C	-	-	D	-	A	B	A	A	A	A	-	B	A	-	A	A	-	D	B	-	D	A	A	A
Lead Sulfamate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	A	-	-	-	-	A	B	C	A	D	C	A
Ligroin[3]	-	-	A	-	-	-	-	A	-	-	-	-	-	-	-	D	A	-	-	-	D	-	-	A	-	A	A	-	B	A	D	A
Lime	-	A	A	-	C	A	-	A	-	A	-	-	A	-	-	A	D	-	C	-	-	-	A	A	-	A	A	C	B	D	-	A
Lubricants	-	A	A	-	A	A	A	B	-	-	-	-	A	-	A	-	A	A	B	-	A	A	A	A	-	A	A	C	D	-	D	A
Magnesium Carbonate	-	A	A	A	-	-	B	-	-	-	-	-	A	-	-	A	A	-	-	B	A	-	-	A	-	-	A	-	A	A	-	A
Magnesium Chloride	B	B	B	A	D	A	A	B	C	D	C	-	A	B	A	A	A	A	-	B	A	A	-	A	-	A	A	-	A	A	A	A
Magnesium Hydroxide	A	A	A	-	D	A	A	C	B	B	B	A	A	-	A	A	A	A	-	B	A	A	A	A	-	A	B	-	B	-	C	A
Magnesium Nitrate	-	A	A	A	-	A	A	-	-	-	-	-	A	-	A	A	A	A	-	B	A	-	-	A	-	A	A	-	A	-	-	A
Magnesium Oxide	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	A	-	-	A	-	A	A	-	A
Magnesium Sulfate	B	B	A	-	B	A	B	B	B	C	B	-	A	B	A	A	A	A	-	B	A	A	A	A	-	A	A	-	A	D	C	A
Maleic Acid	C	A	A	A	B	A	A	C	-	-	B	-	A	B	A	A	C	A	-	-	C	-	A	A	-	A	D	-	A	D	D	A
Maleic Anhydride	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	A	A	-	A	D	-	D	-	D	A
Malic Acid	B	A	A	-	C	-	A	D	-	-	D	-	A	-	A	-	-	A	-	-	-	-	-	A	-	B	-	-	A	-	A	-
Mash	-	A	A	-	-	-	-	A	-	-	-	-	-	-	-	A	A	-	-	-	-	-	A	A	-	-	A	-	A	-	-	A
Mayonnaise	A	A	A	-	D	-	-	D	-	D	D	-	-	-	A	A	A	A	B	-	A	-	A	A	-	A	A	-	-	-	-	A
Melamine	-	D	D	-	-	-	-	D	-	-	-	-	-	-	-	-	D	-	-	-	-	-	A	A	-	-	C	-	-	-	-	A
Mercuric Chloride (Dilute Solution)	D	D	D	D	D	A	B	D	D	D	D	-	A	A	A	A	A	A	-	B	A	-	A	A	-	A	A	-	A	A	A	A
Mercuric Cyanide	A	A	A	-	D	A	-	D	-	-	D	-	A	-	A	A	A	-	-	B	A	-	A	A	-	-	A	-	-	-	-	A
Mercury	A	A	A	A	C	C	A	D	D	A	A	-	A	-	A	A	A	A	-	B	A	-	A	A	-	A	A	-	A	A	A	A
Methanol (See Alcohols, Methyl)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl Acetate	A	-	A	-	A	-	A	A	-	-	B	-	-	-	A	-	A	-	D	-	-	-	A	A	-	D	D	D	B	B	D	-
Methyl Acrylate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	D	D	-	B	B	D	A
Methyl Acetone	A	-	A	-	A	-	-	A	-	A	A	-	-	-	A	D	A	-	-	-	-	-	-	A	-	D	D	-	D	-	-	C
Methyl Alcohol (10%)	A	-	A	-	C	-	A	C	-	-	B	-	A	-	A	-	-	A	-	-	-	-	-	-	-	-	B	-	-	-	A	A
Methyl Bromide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	D	-	-	A	A	-	A	B	-	D	D	D	B
Methyl Butyl Ketone	-	-	A	-	A	-	-	-	-	-	-	-	-	-	-	D	B	-	-	-	-	-	A	A	-	D	D	C	D	A	D	B
Methyl Cellosolve	-	-	-	-	A	-	-	A	-	-	-	-	-	-	-	C	B	-	-	-	A	-	A	A	-	D	D	-	D	B	D	C
Methyl Chloride	-	A	A	-	D	A	A	A	-	-	-	A	D	-	A	D	A	A	-	D	D	-	A	A	-	A	D	D	D	C	D	A
Methyl Dichloride	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D	A	-	-	-	-	-	A	A	-	A	D	-	D	D	D	A
Methyl Ethyl Ketone	-	A	A	-	A	A	A	A	-	-	-	D	D	-	A	D	B	A	D	D	A	A	A	A	-	D	D	C	D	A	D	B
Methyl Isobutyl Ketone[2]	-	-	A	-	-	A	A	-	-	-	-	D	D	-	A	D	B	A	D	-	C	A	A	A	-	D	D	C	D	C	D	B
Methyl Isopropyl Ketone	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	D	B	A	-	-	-	-	A	A	-	D	D	B	D	B	D	B

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type I)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Methyl Methacrylate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	D	D	-	D	D	D	A
Methylamine	A	-	A	-	A	-	-	D	-	B	B	-	-	-	-	B	D	-	-	-	-	-	A	A	-	-	B	-	-	-	-	A
Methylene Chloride	A	A	A	-	A	A	A	A	C	-	B	D	D	-	A	D	A	D	-	D	D	-	A	A	-	D	D	-	D	D	D	A
Milk	A	A	A	A	A	-	-	C	C	D	D	-	A	-	-	A	A	A	B	B	A	-	A	A	A	A	A	B	A	A	A	A
Molasses	A	A	A	A	A	-	-	A	B	A	A	-	A	-	-	B	A	A	-	B	A	-	A	A	A	A	A	-	A	-	-	A
Mustard	A	A	A	A	B	-	-	B	-	C	B	-	A	-	-	B	B	A	B	-	A	-	A	A	-	A	B	C	C	-	-	A
Naptha	A	A	A	A	A	A	A	B	-	B	B	A	A	C	A	D	A	A	C	D	A	A	A	A	-	A	B	D	D	D	D	A
Napthalene	B	A	B	-	B	A	A	C	-	B	A	A	D	-	A	D	A	-	-	D	B	A	A	A	-	B	D	-	D	D	D	A
Nickel Chloride	-	A	B	-	D	A	A	D	-	D	-	A	A	B	A	A	B	A	-	B	A	-	A	A	-	A	A	-	A	A	A	A
Nickel Sulfate	B	A	B	-	D	A	B	C	C	D	D	A	A	A	A	A	B	A	-	B	A	-	A	A	-	A	A	-	A	A	C	A
Nitric Acid (10% Solution)	A	A	A	A	D	A	A	D	-	D	D	A	A	B	A	A	D	D	C	B	A	D	C	B	D	A	D	-	D	B	D	A
Nitric Acid (20% Solution)	-	A	A	A	D	A	A	D	-	D	-	B	A	B	A	A	D	D	D	B	A	C	D	C	D	A	D	-	D	D	D	B
Nitric Acid (50% Solution)	-	A	A	A	D	A	A	D	-	D	-	B	A	B	A	A	D	D	D	C	D	C	D	A	-	A	D	-	D	D	D	D
Nitric Acid (Concentrated Solution)	-	D	B	A	B	A	B	D	D	D	-	-	D	C	A	D	D	D	D	D	D	C	D	A	C	B	D	-	D	D	D	D
Nitrobenzene[2]	B	A	B	-	C	A	B	D	-	B	B	D	D	D	A	D	B	C	D	D	C	B	A	A	-	D	D	D	D	D	D	B
Oils																																
Aniline	-	A	A	-	C	A	D	A	-	A	-	-	D	-	A	D	D	C	D	-	A	-	A	A	-	A	D	-	D	B	D	A
Anise	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	-	-	-	D	-	-	A
Bay	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	A	-	-	D	-	-	A
Bone	-	A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	A	A	-	D	-	-	A
Castor	-	A	A	-	A	-	-	A	-	A	-	-	A	-	-	-	A	-	-	-	-	-	A	A	A	A	A	-	A	B	A	A
Cinnamon	-	A	A	-	-	-	-	-	-	-	-	-	-	-	A	-	A	-	-	-	A	-	A	A	-	D	-	-	D	-	-	A
Citric	-	A	A	-	-	-	-	D	-	D	-	-	-	-	-	-	A	A	-	-	A	-	A	A	-	A	A	-	D	-	-	A
Clove	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	B	-	A	A	-	-	A	-	-	-	-	A
Coconut	-	A	A	-	B	-	-	A	-	A	-	-	-	-	-	-	A	A	-	-	A	-	A	A	-	A	A	-	A	A	D	A
Cod Liver	-	A	A	-	B	-	-	-	-	-	-	-	-	-	-	-	A	A	C	-	A	-	A	A	-	A	A	-	B	A	D	A
Corn	-	A	A	A	B	-	-	B	-	A	-	-	-	-	-	-	A	A	C	-	A	-	A	A	-	A	A	-	D	C	D	A
Cotton Seed	B	A	A	A	B	-	-	B	-	A	C	-	A	-	A	-	A	A	C	-	A	A	A	A	-	A	A	-	D	C	D	A
Creosote[2]	-	A	A	-	A	-	-	-	-	-	-	-	-	-	-	-	D	-	-	-	D	-	A	A	-	A	A	-	B	D	D	A
Diesel Fuel (2D, 3D, 4D, 5D)	-	A	A	-	A	-	-	A	-	-	-	-	-	-	-	D	A	A	-	-	A	A	A	A	-	A	A	-	D	D	D	A
Fuel (1, 2, 3, 5A, 5B, 6)	-	A	A	-	A	A	A	A	-	-	-	-	A	-	A	D	A	-	-	-	B	-	A	A	-	A	B	-	D	D	D	A
Ginger	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	A	A	-	A	-	-	A
Hydraulic (See Hydraulic)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lemon	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	D	-	A	A	-	A	-	-	D	-	-	A
Linseed	-	A	A	A	A	-	-	A	-	A	-	-	A	B	-	-	A	A	C	-	A	-	A	A	A	A	A	-	D	D	D	A
Mineral	A	A	A	A	A	-	-	A	-	A	B	-	A	-	-	B	A	A	-	-	B	A	A	A	A	A	A	-	B	D	D	A
Olive	A	A	A	-	A	-	-	B	-	A	B	-	A	-	A	-	A	A	-	-	A	-	A	A	-	A	A	C	B	-	D	A
Orange	-	A	A	-	-	-	-	-	-	-	-	-	-	-	A	-	A	A	-	-	A	-	A	A	-	A	A	-	D	-	-	A
Palm	-	A	A	-	A	-	-	B	-	-	-	-	A	-	-	-	A	A	-	-	-	-	A	A	-	A	A	-	D	-	-	A
Peanut[3]	-	A	A	-	A	-	-	A	-	A	-	-	A	-	-	-	A	-	-	-	D	-	A	A	-	A	A	-	D	-	D	A
Peppermint[2]	-	A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	A	-	-	-	D	-	A	A	-	A	D	-	D	-	-	A
Pine	A	A	A	-	A	-	-	D	-	C	B	-	A	-	A	-	A	-	-	-	-	-	A	A	-	A	A	-	D	-	D	A
Rape Seed	-	A	A	-	-	-	-	A	-	-	-	-	A	-	-	-	A	-	-	-	-	-	A	A	-	A	B	-	D	-	D	A
Rosin	-	A	A	-	A	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	A	-	A	A	-	A	A	-	-	-	-	A
Sesame Seed	-	A	A	-	A	-	-	A	-	A	-	-	A	-	-	-	A	-	-	-	-	-	A	A	-	A	A	-	D	-	-	A
Silicone	-	A	A	-	-	-	-	A	-	A	-	-	-	-	-	A	A	A	-	-	A	-	A	A	A	A	A	-	A	-	A	A
Soybean	-	A	A	-	A	-	-	B	-	A	-	-	A	-	-	-	A	A	-	-	A	-	A	A	-	A	A	-	D	-	D	A
Sperm	-	A	A	-	-	-	-	A	-	-	-	-	A	-	-	-	A	-	-	-	-	-	A	A	-	A	A	-	D	-	-	A

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type 1)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Tanning	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	A	A	-	D	-	-	A
Turbine	-	A	A	-	A	-	-	A	-	A	-	-	A	-	-	-	A	-	C	-	-	-	A	A	-	A	A	-	D	-	D	A
Oleic Acid	B	A	A	B	B	-	B	B	C	C	C	-	A	C	A	C	B	A	B	D	C	-	A	A	-	D	B	D	D	D	D	A
Oleum (25%)	-	-	-	-	-	-	A	-	-	-	-	B	D	-	A	D	-	-	-	-	-	-	-	A	-	A	D	D	D	D	-	D
Oleum	B	-	A	-	B	-	-	C	C	-	B	D	D	-	A	-	D	-	-	-	D	-	-	A	-	A	C	D	D	D	D	A
Oxalic Acid (Cold)	C	A	B	A	C	C	B	B	C	D	D	-	A	B	A	C	C	D	-	A	A	-	A	A	-	A	B	C	B	A	C	A
Paraffin	A	A	A	A	A	-	-	A	-	B	B	A	A	-	A	B	A	A	B	-	A	-	A	A	-	A	A	-	-	-	-	A
Pentane	A	C	C	-	A	-	B	A	-	B	B	-	-	-	A	D	A	A	D	-	-	-	A	A	-	A	A	-	B	D	D	A
Perchloroethylene[2]	B	A	A	-	A	-	-	C	-	B	B	A	-	-	A	D	A	-	D	-	D	A	A	A	-	A	C	D	D	D	D	A
Petrolatum	A	-	A	-	B	-	-	B	-	C	C	-	-	-	A	D	A	A	B	-	-	-	A	A	-	A	A	-	B	A	D	A
Phenol (10%)	B	A	A	-	A	-	B	C	-	B	D	-	A	C	A	-	-	D	-	-	-	A	-	-	-	B	D	-	C	D	C	C
Phenol (Carbolic Acid)	B	A	A	A	B	C	A	B	D	D	D	A	A	C	A	C	D	D	-	D	B	A	A	D	A	A	D	-	D	D	D	B
Phosphoric Acid (to 40% Solution)	-	B	A	A	D	A	A	D	D	D	-	-	A	B	A	A	D	D	C	B	A	A	B	C	D	A	D	-	D	B	C	A
Phosphoric Acid (40%-100% Solution)	-	C	B	B	D	B	A	D	D	D	-	-	A	B	A	A	D	D	D	C	A	A	B	D	D	A	D	-	D	B	C	C
Phosphoric Acid (Crude)	-	D	C	C	D	C	A	D	D	D	D	A	-	-	A	-	D	D	D	C	-	A	C	D	-	A	D	-	D	B	-	A
Phosphoric Anhydride (Dry or Moist)	-	A	A	-	-	-	-	-	D	-	-	-	D	D	A	-	-	-	-	-	-	-	A	-	-	D	D	-	D	-	A	-
Phosphoric Anhydride (Molten)	-	A	A	-	D	-	-	D	D	-	-	-	D	-	A	-	-	A	-	D	-	-	-	-	-	D	C	-	D	-	D	A
Photographic Developer	-	C	A	C	C	A	A	-	-	D	-	-	A	-	-	A	C	-	-	B	A	-	A	A	-	A	A	-	A	-	-	A
Phthalic Anhydride	B	A	B	-	B	-	A	B	-	C	C	-	-	-	A	-	-	A	-	-	-	-	-	-	-	A	C	-	-	-	-	-
Picric Acid	B	A	A	-	C	-	A	D	D	D	D	-	A	A	A	-	-	A	-	A	-	-	-	-	-	A	A	D	A	-	A	A
Plating Solutions																																
Antimony Plating 130°F	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	A	-	A	A	D	A	-	-	B
Arsenic Plating 110°F	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	C	-	A	A	D	A	-	-	B
Brass Plating																																
Regular Brass Bath 100°F	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	C	-	A	A	D	A	-	-	B
High Speed Brass Bath 110°F	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	D	-	A	A	D	A	-	-	B
Bronze Plating																																
Copper-Cadmium Bronze Bath R.T.	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	C	-	A	A	D	A	-	-	B
Copper-Tin Bronze Bath 160°F	-	-	A	-	-	A	A	-	-	-	-	-	D	-	A	A	-	A	-	-	A	-	-	D	-	A	A	D	B	-	-	C
Copper-Zinc Bronze Bath 100°F	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	C	-	A	A	-	A	-	-	B
Cadmium Plating																																
Cyanide Bath 90°F	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	C	-	A	A	-	A	-	-	B
Fluoborate Bath 100°F	-	-	A	-	-	D	A	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	D	-	A	B	-	C	-	-	B
Chromium Plating																																
Chromic-Sulfuric Bath 130°F	-	-	C	-	-	A	A	-	-	-	-	-	A	-	A	D	-	D	-	-	A	-	-	A	-	C	D	-	D	-	-	D
Fluosilicate Bath 95°F	-	-	C	-	-	C	A	-	-	-	-	-	A	-	A	D	-	D	-	-	A	-	-	B	-	C	D	-	D	-	D	D
Fluoride Bath 130°F	-	-	D	-	-	C	A	-	-	-	-	-	A	-	A	D	-	D	-	-	A	-	-	B	-	C	D	-	D	-	-	D
Black Chrome Bath 115°F	-	-	C	-	-	A	A	-	-	-	-	-	A	-	A	D	-	D	-	-	A	-	-	A	-	C	D	-	D	-	-	D
Barrel Chrome Bath 95°F	-	-	D	-	-	C	A	-	-	-	-	-	A	-	A	D	-	D	-	-	A	-	-	A	-	C	D	-	D	-	-	D
Copper Plating (Cyanide)																																
Copper Strike Bath 120°F	-	-	-	-	A	A	A	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-	-	C	-	B	-	-	A	-	-	-
Rochelle Salt Bath 150°F	-	-	A	-	-	A	A	-	-	-	-	-	D	-	A	A	-	A	-	-	A	-	-	D	-	A	A	-	B	-	-	C
High Speed Bath 180°F	-	-	A	-	-	A	A	-	-	-	-	-	D	-	A	A	-	A	-	-	A	-	-	D	-	A	A	-	B	-	-	C
Copper Plating (Acid)																																
Copper Sulfate Bath R.T.	-	-	D	-	-	A	A	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	D	-	A	A	-	A	-	-	D
Copper Fluoborate Bath 120°F	-	-	D	-	-	D	A	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	D	-	A	B	-	C	-	-	D
Copper (Misc.)																																
Copper Pyrophosphate 140°F	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	B	-	A	A	-	A	-	-	B
Copper (Electroless) 140°F	-	-	-	-	-	-	-	D	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	D	-	A	D	-	D	-	-	B

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type I)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Gold Plating																																
Cyanide 150°F	-	-	A	-	-	A	A	C	-	-	-	-	D	-	A	A	-	A	-	-	A	-	-	B	-	A	A	-	A	-	-	D
Neutral 75°F	-	-	C	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	A	-	A	A	-	A	-	-	A
Acid 75°F	-	-	C	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	A	-	A	A	-	A	-	-	A
Indium Sulfamate Plating R.T.	-	-	C	-	-	A	A	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	A	-	A	A	-	A	-	-	A
Iron Plating																																
Ferrous Chloride Bath 190°F	-	-	D	-	-	A	D	-	-	-	-	-	D	-	A	A	-	D	-	-	C	-	-	A	-	A	B	-	D	-	-	D
Ferrous Sulfate Bath 150°F	-	-	C	-	-	A	A	-	-	-	-	-	D	-	A	A	-	D	-	-	A	-	-	A	-	A	A	-	B	-	-	D
Ferrous Am. Sulfate Bath 150°F	-	-	C	-	-	A	A	-	-	-	-	-	D	-	A	A	-	D	-	-	A	-	-	A	-	A	A	-	B	-	-	D
Sulfate-Chloride Bath 160°F	-	-	D	-	-	A	D	-	-	-	-	-	D	-	A	A	-	D	-	-	A	-	-	A	-	A	B	-	C	-	-	D
Fluoborate Bath 145°F	-	-	D	-	-	D	B	-	-	-	-	-	D	-	A	A	-	D	-	-	A	-	-	D	-	A	B	-	C	-	-	D
Sulfamate 140°F	-	-	D	-	-	A	B	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	A	-	A	A	-	A	-	-	A
Lead Fluoborate Plating	-	-	C	-	-	D	A	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	D	-	A	B	-	C	-	-	A
Nickel Plating																																
Watts Type 115-160°F	-	-	C	-	-	A	A	-	-	-	-	-	D	-	A	A	-	A	-	-	A	-	-	A	-	A	A	-	A	-	-	D
High Chloride 130-160°F	-	-	C	-	-	A	A	-	-	-	-	-	D	-	A	A	-	D	-	-	A	-	-	A	-	A	A	-	B	-	-	D
Fluoborate 100-170°F	-	-	C	-	-	D	A	D	-	-	-	-	D	-	A	A	-	D	-	-	A	-	-	D	-	A	B	-	C	-	-	D
Sulfamate 100-140°F	-	-	C	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	A	-	A	A	-	A	-	-	A
Electroless 200°F	-	-	-	-	-	-	-	-	-	-	-	-	D	-	A	D	-	D	-	-	D	-	-	A	-	A	D	-	D	-	-	B
Rhodium Plating 120°F	-	-	D	-	-	D	D	-	-	-	-	-	A	-	A	A	D	D	-	-	A	-	-	A	-	A	A	-	B	-	-	A
Silver Plating 80-120°F	-	-	A	-	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	B	-	A	A	-	A	-	-	A
Tin-Fluoborate Plating 100°F	-	-	C	-	-	D	A	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	D	-	A	B	-	C	-	-	A
Tin-Lead Plating 100°F	-	-	C	-	-	D	A	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	D	-	A	B	-	C	-	-	A
Zinc Plating																																
Acid Chloride 140°F	-	-	D	-	-	A	D	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	A	-	A	A	-	A	-	-	A
Acid Sulfate Bath 150°F	-	-	C	-	-	A	A	-	-	-	-	-	D	-	A	A	-	D	-	-	A	-	-	A	-	A	A	-	B	-	-	D
Acid Fluoborate Bath R.T.	-	-	-	C	-	D	-	-	-	-	-	-	A	-	A	A	-	D	-	-	A	-	-	D	-	A	B	-	C	-	-	A
Alkaline Cyanide Bath R.T.	-	-	-	A	-	A	A	-	-	-	-	-	A	-	A	A	-	A	-	-	A	-	-	D	-	A	A	-	A	-	-	A
Potash	-	A	-	A	C	-	A	C	-	B	-	-	A	B	-	A	B	A	-	B	A	-	A	A	A	A	A	-	B	-	B	A
Potassium Bicarbonate	-	A	-	B	C	A	B	B	-	D	-	A	A	-	A	A	C	A	C	B	A	A	A	A	-	A	A	-	A	-	B	A
Potassium Bromide	A	A	-	B	C	A	B	C	-	D	D	A	A	-	A	A	A	C	-	B	A	C	A	A	-	A	A	-	A	A	B	A
Potassium Carbonate	B	A	-	A	C	A	A	C	-	B	B	A	A	B	A	A	B	A	-	B	A	A	A	A	A	A	B	-	A	-	B	A
Potassium Chlorate	B	A	A	A	B	A	B	B	-	B	B	A	A	B	A	A	B	D	-	B	A	A	A	A	-	A	A	-	A	-	B	A
Potassium Chloride	C	A	A	B	B	A	A	C	C	B	B	A	A	A	A	A	A	B	C	B	A	A	A	A	-	A	A	-	A	A	A	A
Potassium Chromate	-	-	B	B	A	-	B	A	-	A	-	-	A	-	-	A	C	-	-	B	-	A	A	D	-	A	A	-	A	-	B	C
Potassium Cyanide Solutions	B	A	B	A	D	A	A	D	-	B	B	A	A	-	A	A	C	A	-	B	A	A	C	A	-	B	A	-	A	A	A	A
Potassium Dichromate	B	A	A	A	A	A	B	C	-	B	C	A	A	-	A	A	C	D	-	B	A	A	A	A	-	B	A	-	A	A	A	A
Potassium Ferrocyanide	B	A	-	A	C	-	B	A	-	-	C	-	A	-	A	-	-	A	-	A	-	-	-	-	-	-	D	-	-	-	A	A
Potassium Hydroxide (50%)	A	B	B	B	D	C	A	D	D	C	A	D	A	B	A	A	D	A	C	B	A	A	-	D	A	D	B	C	A	A	C	A
Potassium Nitrate	B	A	B	A	B	A	B	B	-	-	B	A	A	C	A	A	B	C	-	B	A	C	A	A	-	B	A	-	A	A	A	A
Potassium Permanganate	B	A	B	B	B	B	B	B	-	B	B	A	A	-	A	A	C	D	C	B	B	A	A	A	-	B	A	-	A	-	B	B
Potassium Sulfate	B	A	B	B	A	A	A	B	B	B	B	A	A	A	A	A	B	C	-	B	A	A	A	A	-	A	A	C	A	A	C	A
Potassium Sulfide	A	A	-	A	B	-	B	B	-	B	B	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-
Propane (Liquified)[1 2]	A	A	-	A	A	-	-	A	A	-	B	-	D	-	A	D	A	A	-	-	D	-	A	A	-	A	A	D	B	D	D	A
Propylene Glycol	B	B	-	A	A	-	-	B	-	B	B	-	-	-	A	-	B	B	B	B	-	-	A	A	-	A	A	-	C	-	-	A
Pyridine	-	C	-	B	B	-	-	-	-	B	A	D	-	D	A	D	D	-	-	C	B	A	A	A	-	D	D	-	D	B	D	A
Pyrogallic Acid	B	A	A	A	B	-	A	B	-	B	B	-	A	-	A	-	D	A	-	-	-	-	A	A	-	A	A	-	-	-	-	A
Rosins	A	A	A	A	A	-	B	A	C	-	C	-	-	-	A	-	B	A	-	-	A	-	A	A	-	-	A	-	-	-	-	A
Rum	-	A	-	A	-	-	-	-	-	-	-	-	A	-	-	A	A	A	-	-	A	-	A	A	-	A	A	-	A	-	-	A

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type 1)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Rust Inhibitors	-	A	-	A	-	-	-	A	-	A	-	-	-	-	-	-	A	-	-	-	A	-	A	A	-	A	A	-	C	-	-	A
Salad Dressing	-	A	-	A	B	-	-	B	-	D	-	-	A	-	-	A	A	A	-	-	A	-	A	A	-	A	A	-	-	-	-	A
Sea Water	A	A	C	A	C	A	-	C	-	-	D	-	A	-	A	A	A	A	-	B	A	-	A	A	A	A	A	B	B	A	A	A
Shellac (Bleached)	A	A	-	A	A	-	-	A	B	B	A	-	-	-	A	-	A	A	-	-	A	-	-	A	-	-	A	-	-	-	-	A
Shellac (Orange)	A	A	-	A	A	-	-	A	C	C	A	-	-	-	A	-	A	A	-	-	A	-	-	A	-	-	A	-	-	-	-	A
Silicone	-	B	-	A	B	-	-	A	-	-	-	-	-	-	-	A	A	A	-	-	A	-	A	A	-	A	A	B	A	A	A	A
Silver Bromide	-	C	C	B	D	-	-	-	-	-	-	-	-	-	-	A	C	-	-	-	-	-	A	-	-	-	-	-	-	-	-	A
Silver Nitrate	B	A	B	A	D	A	A	D	-	D	D	A	A	B	A	A	C	A	-	B	A	-	A	A	-	A	C	-	A	C	A	A
Soap Solutions[1]	A	A	A	A	C	A	B	B	-	B	A	-	B	B	A	A	A	A	-	B	A	A	A	A	A	A	A	B	B	-	C	A
Soda Ash (See Sodium Carbonate)	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium Acetate	B	A	A	B	B	A	-	B	-	C	C	A	A	-	A	A	B	A	-	B	A	-	A	A	-	D	D	-	C	-	A	A
Sodium Aluminate	B	-	-	A	C	B	B	B	-	-	C	-	-	-	A	A	B	A	-	-	-	A	A	A	-	A	A	-	A	A	B	A
Sodium Bicarbonate	B	A	A	A	A	A	-	B	A	C	C	A	A	B	A	A	B	A	B	B	A	A	A	A	A	A	A	C	A	A	A	A
Sodium Bisulfate	A	A	-	A	D	B	B	C	C	D	D	A	A	B	A	A	B	C	C	B	A	A	A	A	-	B	A	C	A	-	A	A
Sodium Bisulfite	-	A	-	A	A	A	B	C	-	D	-	A	A	B	A	A	B	D	B	B	A	A	A	A	-	A	A	C	A	-	A	A
Sodium Borate	B	A	-	A	C	-	A	A	-	C	C	-	C	-	A	-	-	A	-	A	-	-	-	-	-	A	-	B	A	-	-	-
Sodium Carbonate	B	A	B	B	C	A	A	B	B	B	B	A	A	B	A	A	A	A	C	B	A	A	B	A	-	A	A	-	A	A	A	A
Sodium Chlorate	B	A	-	A	B	A	B	B	-	-	C	A	A	B	A	A	D	A	-	B	A	A	A	A	-	A	D	-	A	-	A	A
Sodium Chloride	B	A	C	B	C	A	A	B	C	B	C	A	A	B	A	A	A	A	B	B	A	A	A	A	A	A	A	C	A	A	B	A
Sodium Chromate	A	A	A	-	D	-	B	B	-	B	B	-	-	-	A	A	D	A	-	-	A	A	A	B	-	B	A	-	A	-	-	C
Sodium Cyanide	B	A	-	A	D	A	-	D	D	B	B	A	A	-	A	A	D	C	-	B	A	A	A	A	-	A	A	D	A	A	A	A
Sodium Fluoride	B	C	-	C	C	A	A	C	-	D	D	-	D	D	A	-	-	A	-	C	-	-	-	-	-	B	D	-	D	-	D	A
Sodium Hydrosulfite	-	-	-	-	A	-	A	C	-	-	-	-	C	A	A	-	-	A	-	-	-	-	-	A	-	A	-	-	A	-	A	-
Sodium Hydroxide (20%)	-	A	A	A	D	A	A	C	D	A	-	A	A	B	A	A	D	C	C	B	A	A	C	D	A	A	A	D	B	A	A	A
Sodium Hydroxide (50% Solution)	-	A	B	-	D	A	A	C	D	B	-	D	A	B	A	A	D	C	C	C	A	B	C	D	A	D	D	D	C	-	A	A
Sodium Hydroxide (80% Solution)	-	A	D	-	D	A	B	C	D	C	-	-	A	B	A	A	D	C	C	C	A	B	C	D	A	B	D	D	C	-	B	A
Sodium Hypochlorite[3] (to 20%)	-	C	C	C	C	A	A	D	D	D	-	-	A	B	A	A	D	A	-	B	C	C	D	A	B	A	C	D	D	B	C	B
Sodium Hypochlorite	D	-	D	-	D	A	A	D	-	D	D	A	A	-	A	A	-	A	-	-	C	C	-	D	-	B	B	C	A	-	-	A
Sodium Hyposulfate	-	A	A	-	D	-	-	D	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	C	C
Sodium Metaphosphate[2]	A	-	A	-	A	-	-	C	C	B	B	-	-	-	A	-	B	A	-	-	D	-	A	A	-	A	A	-	B	A	A	A
Sodium Metasilicate	A	-	A	-	B	-	-	B	-	C	C	-	-	-	A	-	D	-	-	-	-	-	A	-	-	A	A	D	A	-	-	A
Sodium Nitrate	B	A	A	A	A	A	B	B	C	A	B	A	A	B	A	A	B	A	-	B	A	-	A	A	A	D	C	D	B	A	C	A
Sodium Perborate	B	-	C	-	B	-	-	C	C	B	B	-	-	-	A	A	B	A	-	-	A	-	A	A	-	A	B	D	B	A	C	A
Sodium Peroxide	B	A	A	-	C	-	B	C	C	D	C	-	A	-	A	-	D	D	-	-	-	-	A	A	-	A	C	D	B	A	C	A
Sodium Polyphosphate (Mono, Di, Tribasic)	-	A	A	-	D	A	A	C	-	-	-	-	-	-	A	A	B	-	-	-	-	-	A	A	-	A	A	-	D	A	A	A
Sodium Silicate	B	A	B	A	C	A	B	C	C	-	B	-	A	B	A	A	C	A	-	-	A	-	A	A	-	A	A	-	A	A	A	A
Sodium Sulfate	B	A	A	C	B	A	B	B	B	A	B	-	A	-	A	A	B	A	-	B	A	A	A	A	-	A	A	-	A	A	C	A
Sodium Sulfide	B	A	B	-	D	A	B	D	D	A	B	-	A	B	A	A	B	A	-	B	A	A	A	A	-	A	C	-	A	A	C	A
Sodium Sulfite	-	C	C	-	C	A	A	C	-	A	-	-	A	A	A	-	-	D	-	A	-	-	A	A	-	A	A	-	A	-	A	A
Sodium Tetraborate	-	-	A	-	-	-	-	-	-	-	-	-	A	-	-	A	B	-	-	-	-	-	A	A	-	A	A	-	-	-	-	A
Sodium Thiosulfate ("Hypo")	A	A	A	-	B	A	-	D	D	C	B	-	A	-	A	A	C	A	-	-	A	A	A	A	-	A	B	-	A	A	C	A
Sorghum	-	A	A	-	-	-	-	-	-	A	-	-	-	-	-	-	A	A	-	-	-	-	A	A	-	A	A	-	A	-	-	A
Soy Sauce	-	A	A	-	A	-	-	A	-	D	-	-	-	-	-	A	A	A	-	-	-	-	A	A	-	A	A	-	A	-	D	A
Stannic Chloride	D	D	D	-	D	A	B	D	-	D	D	A	A	-	A	A	C	A	-	B	A	-	-	A	-	A	A	D	A	A	A	A
Stannic Fluoborate	-	-	A	-	-	-	-	-	-	D	-	-	-	-	-	A	C	-	-	-	-	-	-	A	-	A	A	-	A	-	-	A
Stannous Chloride	D	D	C	-	D	A	A	D	-	D	D	-	A	A	A	-	-	D	-	A	-	-	-	-	-	B	C	D	D	-	A	A
Starch	B	A	A	-	A	-	-	B	-	C	C	-	A	-	A	A	A	A	-	B	-	-	A	A	-	A	A	-	A	-	-	A
Stearic Acid[2]	B	A	A	A	B	A	A	C	C	C	C	A	A	B	A	A	A	A	-	B	D	-	A	A	A	A	B	D	B	B	C	A

	302 Stainless Steel	304 Stainless Steel	316 Stainless Steel	440 Stainless Steel	Aluminum	Titanium	Hastelloy C	Cast Bronze	Brass	Cast Iron	Carbon Steel	Kynar	PVC (Type I)	Tygon (E-3606)	Teflon	Noryl	Polyacetal	Nylon	Cycolac (ABS)	Polyethylene	Polypropylene	Ryton	Carbon	Ceramic	Ceramagnet "A"	Viton	Buna-N (Nitrile)	Silicon	Neoprene	Ethylene Propylene	Rubber (Natural)	Epoxy
Stoddard Solvent	A	A	A	A	A	A	A	A	A	B	B	A	A	D	A	D	A	A	B	D	D	A	A	A	-	A	B	D	D	D	D	A
Styrene	A	A	A	-	A	-	-	A	-	-	A	-	-	-	A	A	A	-	-	-	-	-	A	A	-	B	D	D	D	D	D	A
Sugar (Liquids)	A	A	A	A	A	-	A	A	-	B	B	-	-	-	A	A	A	A	B	-	A	-	A	A	A	A	A	-	B	-	A	A
Sulfate Liquors	-	C	C	-	B	-	A	C	-	-	-	-	-	-	-	-	D	-	-	-	A	-	A	A	-	-	-	-	C	-	-	A
Sulfur Chloride	-	D	D	D	D	-	-	C	D	-	-	-	A	C	A	A	D	A	-	A	D	-	A	C	-	A	D	-	D	D	D	C
Sulfur Dioxide[2]	-	A	A	C	A	A	B	B	-	-	-	B	D	B	A	D	B	D	D	C	D	A	A	A	-	D	D	C	B	A	D	A
Sulfur Dioxide (Dry)	A	A	A	-	A	-	A	A	C	A	B	-	D	-	A	-	-	A	-	D	-	-	A	A	-	D	-	-	D	-	D	D
Sulfur Trioxide (Dry)	A	A	C	-	A	-	-	B	-	B	B	-	A	B	A	D	D	D	-	-	-	-	B	A	-	A	D	-	D	B	C	A
Sulfuric Acid (to 10%)	-	D	C	C	C	A	A	D	D	D	-	A	A	B	A	A	D	D	B	B	A	A	A	A	-	A	C	-	D	D	C	A
Sulfuric Acid (10%-75%)[2]	-	D	D	D	D	C	B	D	D	D	-	A	A	B	A	B	D	D	B	C	A	B	A	D	C	A	D	-	D	D	D	B
Sulfuric Acid (75%-100%)	-	-	D	-	-	D	B	-	D	-	-	A	B	-	A	A	-	D	-	-	B	C	-	A	-	A	D	-	D	-	-	D
Sulfurous Acid	C	C	B	C	C	A	B	D	-	D	D	-	A	B	A	A	D	D	-	B	A	-	B	A	-	A	C	D	B	B	C	A
Sulfuryl Chloride	-	-	-	-	-	-	-	-	-	-	-	-	A	-	A	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	A
Syrup	-	A	A	A	A	-	-	D	-	-	-	-	A	-	-	A	A	A	B	-	A	-	A	A	A	A	A	-	B	-	A	A
Tallow	-	A	A	-	A	-	-	-	-	-	-	-	-	-	-	A	A	A	-	C	-	-	A	A	-	A	A	-	-	-	-	A
Tannic Acid	B	A	A	A	C	A	B	B	-	C	C	A	A	B	A	A	B	D	-	B	A	-	A	A	A	A	D	C	A	A	A	A
Tanning Liquors	-	A	A	-	C	A	A	A	-	-	-	-	A	B	A	-	B	-	-	-	A	-	A	A	-	A	C	-	-	-	-	A
Tartaric Acid	B	A	B	B	C	A	B	A	C	D	D	A	A	B	A	A	B	A	-	B	A	-	A	A	-	A	D	C	A	-	A	A
Tetrachlorethane	-	-	A	-	-	A	A	-	-	-	-	-	D	-	A	D	A	A	-	-	A	-	A	A	-	A	D	-	-	D	D	A
Tetrahydrofuran	-	A	A	-	D	-	-	D	-	D	A	D	D	-	A	D	A	A	-	D	C	A	A	A	-	D	D	-	D	B	D	A
Toluene, Toluol[3]	A	A	A	-	A	A	A	A	A	A	A	A	D	D	A	D	A	A	D	D	D	A	A	A	A	C	D	D	D	D	D	A
Tomato Juice	A	A	A	-	A	-	-	C	-	C	C	-	-	-	A	A	B	A	B	-	A	A	A	A	-	A	A	-	A	-	-	A
Trichlorethane	-	C	A	-	C	A	A	C	-	C	-	-	-	-	A	D	A	-	-	-	-	-	A	A	-	A	D	D	D	D	D	A
Trichlorethylene[2]	B	A	A	-	B	A	A	B	A	C	B	A	D	-	A	D	A	C	D	D	D	C	A	A	C	A	D	D	D	D	D	A
Trichloropropane	-	-	A	-	-	-	-	A	-	-	-	-	-	-	-	D	A	-	D	-	-	-	A	A	-	A	A	-	A	-	-	A
Tricresylphosphate	-	-	A	-	-	B	A	A	-	-	-	-	D	-	A	A	C	-	-	-	-	-	A	A	-	B	D	-	D	A	-	A
Triethylamine	-	-	-	-	-	-	-	A	-	-	-	-	A	-	-	B	D	-	-	-	-	-	A	A	-	A	A	D	B	-	-	A
Turpentine[3]	B	A	A	-	C	-	A	B	C	B	B	A	A	B	A	D	A	A	-	D	B	A	A	A	-	A	D	-	D	D	D	A
Urine	-	A	A	-	B	-	-	C	-	B	-	-	A	-	-	A	A	A	-	B	A	-	A	A	-	A	A	-	D	A	-	A
Vegetable Juice	-	A	A	-	A	-	-	C	-	D	-	-	-	-	-	A	A	A	-	-	-	-	A	A	-	A	A	B	D	-	D	A
Vinegar	A	A	A	A	D	A	A	B	B	C	D	A	A	-	A	A	B	A	B	B	A	A	A	A	A	A	C	-	B	A	C	A
Varnish (Use Viton for Aromatic)	A	A	A	A	A	-	-	A	B	-	C	-	-	-	A	D	A	A	-	-	A	-	A	A	A	A	B	C	D	-	D	A
Water, Acid, Mine	-	A	A	-	C	-	-	C	D	C	-	-	A	B	-	A	D	A	B	-	A	B	A	A	-	A	A	-	B	-	B	A
Water, Distilled, Lab Grade 7	-	A	A	-	B	-	-	A	-	D	-	-	A	B	A	A	A	A	A	-	A	A	A	A	A	A	A	-	B	A	A	A
Water, Fresh	A	A	A	-	A	-	-	A	C	B	D	-	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	-	B	A	A	A
Water, Salt	-	A	A	-	B	-	-	B	C	D	-	-	A	B	-	A	A	A	-	-	A	A	A	A	A	A	A	-	B	A	A	A
Weed Killers	-	A	A	-	C	-	-	C	-	-	-	-	-	-	-	-	A	A	-	-	-	-	A	A	-	A	B	-	C	-	-	A
Whey	-	A	A	-	B	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	A	-	A	A	-	-	-	-	A
Whiskey and Wines	A	A	A	A	D	-	-	B	B	D	D	-	A	-	A	A	A	A	-	B	A	-	A	A	-	A	A	B	A	A	A	A
White Liquor (Pulp Mill)	-	A	A	-	-	-	A	D	-	C	-	-	A	-	A	A	D	A	-	-	A	-	A	A	-	A	A	-	A	-	-	A
White Water (Paper Mill)	-	A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	B	A	-	-	A	-	A	A	-	A	-	-	A	-	-	A
Xylene[2]	A	A	A	-	A	-	A	A	A	A	B	A	D	-	A	D	A	A	D	D	D	A	A	A	A	A	D	D	D	D	D	A
Zinc Chloride	D	D	B	B	D	A	B	D	D	D	D	A	A	-	A	A	C	A	-	B	A	A	A	A	-	A	A	-	A	A	A	A
Zinc Hydrosulfite	-	-	A	-	D	-	-	D	-	D	-	-	-	-	-	A	C	-	-	-	-	A	A	A	-	-	A	-	A	A	-	A
Zinc Sulfate	B	A	A	A	D	A	B	B	C	C	D	A	C	B	A	A	C	A	-	B	A	A	A	A	-	A	A	-	A	A	C	A

15 Glossary

Accuracy — A scale’s ability to provide a weight reading equal to the actual weight placed on the scale. A scale’s accuracy is usually measured against a recognized standard, such as NIST Certified Test Weights.

Calibration — The process of equating the graduations on a scale to the actual weight values that they represent. It involves adjusting the scale’s indicator so that it reads zero when no weight is on the scale and reads the full weight capacity when that weight is placed on the scale.

Clevis — A U-shaped connector with holes drilled through the arms. A pin is fitted through the holes to attach the clevis to another component.

Compression — The act of squeezing or pressing down on a material. A compression weigh module is designed so that its top plate and base plate will be squeezed toward each other when weight is applied to it.

Creep — The gradual deflection of a material when a steady force is applied to it. Creep error is the change in a weight reading when a weight is left on a scale for a length of time.

Deflection — The bending or twisting of a material when force is applied to it.

Distributed Loading — A type of loading in which an object is placed on a scale so that its full weight is spread over all of the scale’s load cells.

Dynamic Loading — A situation in which the weight applied to a scale is in motion. One example is a conveyor system used to weigh objects as they move along the conveyor.

Electromagnetic Interference (EMI) — The disturbance of an electrical device’s operation that is caused when the device picks up electromagnetic radiation from an outside source.

Full End Loading — A type of loading in which an object is placed on a scale so that its full weight is temporarily concentrated over the load cells at one end of the scale. Full end loading is common with conveyor systems, where the object to be weighed moves across the scale from the front end to the back end.

Hermetic Seal — A metal cover welded or soldered in place to protect the strain gauges in a load cell. This type of airtight seal is commonly used for harsh environments.

Hysteresis — A scale's ability to repeat measurements of weights as they are added and removed. When there is a hysteresis error, a scale will give different weight readings for the same applied load, depending on whether weight is being added to or removed from the scale. A scale with a hysteresis error might display low readings as weight is being added and high readings as it is being removed.

Increment — The smallest change in weight that a digital scale can detect (also called a division).

Indicator — In a digital scale, the indicator is the part of the scale that receives analog signals transmitted by the load cells and displays them as weight readings.

Linearity — A scale’s ability to maintain a consistent counts-to-load ratio from zero to full load capacity. When a scale has a linearity error, it reads correctly at zero and at full load capacity but incorrectly in between those two points.

Live Load — The downward force exerted by an object or material being weighed on a scale.

Live-to-Dead Connection — A mechanical connection between a scale and an object that you do not want to weigh. A common example is piping connected to a tank scale. If the connection is not flexible enough to allow the scale to move freely, the piping can push or pull on the scale and produce inaccurate weight readings.

Load — A mechanical force applied to a scale or other object.

Load Cell — The component of a scale that detects the mechanical force exerted by a weight and converts it to an electrical signal.

Potted Seal — A layer of organic sealing compound used to protect the strain gauges in a load cell. It is not as effective as a hermetic seal, which is often preferred for harsh environments.

Radio Frequency Interference — The disturbance of an electrical device's operation that is caused when the device picks up radio frequency emissions from an outside source.

Rated Capacity — The heaviest load that a scale is designed to withstand under normal conditions.

Repeatability — a scale's ability to display a consistent weight reading each time the same weight is placed on the scale. It is especially important for batching and filling applications, which require that the same amount of a material be used for each batch.

Resolution — A scale's ability to detect changes in weight. For a digital scale, resolution is measured in increment size, which is the smallest weight change that the scale can detect.

Safe Overload — The maximum weight that can be applied to a load cell without causing it to fail (typically 150% of rated capacity).

Seismic Loading — Forces exerted on a scale or its support structure by earthquakes or other vibrations of the earth.

Shear Force — A horizontal force exerted on a scale.

Shock Loading — Forces exerted on a scale or its support structure when an object strikes it. Shock forces can be created when an object is dropped on a scale or when a vehicle runs into a scale

Spring Rate — A measure of a material's flexibility. The spring rate constant for a load cell is its rated capacity divided by load cell deflection at rated capacity.

Static Loading — A situation in which the load applied to a scale will be weighed while not in motion.

Strain Gauge — A wire or series of wires that measures the strain a force exerts on an object. When a strain gauge is attached to a load cell, it measures how much a weight causes the load cell to deflect. The strain gauges stretches as the load cell deflects, increasing the wire's resistance to an electric current being transmitted through it.

Tension — The act of stretching a material. A tension weigh module is designed to stretch as weight is applied to it.

Transducer — A device used to convert energy from one form to another. A load cell is a transducer that converts a mechanical force (weight) to an electrical force (current) which can be used to provide a digital weight reading.

Type Evaluation — The procedure used to test a particular type (or model) of weighing device. In the United States, the National Type Evaluation Program (NTEP) tests a sample of each model of scale. If the tests show that a scale complies with the requirements of NIST Handbook 44, NTEP issues a Certificate of Conformance for that model of scale.

Ultimate Overload — The weight at which a load cell will structurally fail (typically 300% of rated capacity).

Weigh Module — A device that can be attached to a tank or other structure to convert the structure into a scale. Weigh modules are attached to a structure so that they support its full weight. A weigh module system should be designed to provide accurate weight readings and support the structure safely.

Weighbridge — A scale platform. It is designed to transfer the load placed on it to the scale's load cells.

Wind Loading — Forces exerted on a scale or its support structure by wind currents.

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