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1. Introduction

1.1 Purpose

This Practice provides requirements for equipment selection and system design for weight measurement systems.

1.2 Scope

This Practice specifies requirements for design and installation of static, continuous, and scale weigh systems. This Practice does not include criteria for mechanical weigh scales, hydraulic load cells, or pneumatic load cell technology.

2. References

Applicable parts of the following Practices shall be considered complementary to this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted.

2.1 Process Industry Practices (PIP)

- PIP PCEWE001 - Weigh Systems Guidelines

3. Definitions

accuracy: Degree of agreement between the result of a measurement and the true value (e.g., the degree to which the system performs weighing functions within an acceptable or desired tolerance and is stated in percentage of full-scale reading), stated as percent error; measured value minus actual value divided by actual value multiplied by 100.

capacity: The heaviest specified load that can be applied to the load-receiving element without damage or influence on accuracy, repeatability, or linearity.

cHECK rods (or safety check rods): Back up lateral structural locating members that perform the sole function of holding a vessel in check and preventing tipping or wobbling. Safety check rods are not an active part of the weigh system.

continuous weigh system: A system that captures the weight of a discrete object or material as it moves through or across a scale (e.g., weigh feeders, gravimetric feeders, loss-in-weight feeders, etc.). Continuous systems require minimal personnel intervention.

cosine error: An error with the load cell caused by any tilt of the support plane where the signal decreases by 1/cos A (A = the tilt angle).

creep: The change in load cell signal occurring with time while under load and with all environmental conditions and other variables remaining constant. Normally expressed in units of % of applied load, or rated output (RO) over a specified time interval. It is common for characterization to be measured with a constant load at or near capacity.

death load: Fixed weight of the weigh vessel, support structure, and objects fixed to the vessel when the weigh vessel is empty (also called tare weight).

deflection: The change in total dimension along the primary axis of the load cell or support member between no load and full load conditions.
**gross weight:** Sum of the dead load and live load.

**live load:** Weight of the material contained within the weigh vessel that is to be measured (gross weight less the tare weight).

**load cell:** A compression, tension, or bending (load beam) device that produces an output signal proportional to the gross weight applied.

**rated output (RO):** Output corresponding to capacity, equal to the algebraic difference between the signal at (minimum load + capacity) and the signal at minimum load (tare).

**repeatability:** A term meant here to express random errors in a series of measurements taken of the same value. It is the measurement of how closely readings conform to each other. A (weight) measurement may be repeatable without being highly accurate. Repeatability may be the essential requirement for weight measurement.

**scale:** A device that measures the weight of an object (e.g., small scales, bag feeders, cylinder scales, truck scales, etc.). The object can be manually, semi-automatically, or automatically placed on and off the scale.

**static weigh system:** A system that weighs a static object and determines how much material is contained within the object (e.g., load cells, load beams, strain gauges, etc.). Static systems require minimal personnel intervention.

**stay rods:** Restraints intended to rigidly constrain or “stay” a vessel and constitute the primary lateral restraint system for most vessels. Stay rods are an active part of the weigh system, and their load contribution is to the dead or tare weight.

**strain:** Deformation caused by the action of force. Strain is the physical displacement between two points caused by the application of force (load). The difference in placement of two points in this body in those two states expresses the numerical value of strain.

**tare weight:** The weight of an empty container or the allowance or deduction from gross weight.

**(total weight) capacity:** The total weight capacity of the weigh system needed to support the gross weight of the weigh system.

**weigh vessel:** Vessel or container that holds material to be weighed.

### 4. Requirements

#### 4.1 Static Weigh Systems

**Comment:** The accuracy and optimum performance of a static weigh system depends on the instrumentation, vessel design, support structure, piping details, and lateral restraint systems.

#### 4.1.1 General

4.1.1.1 The weigh system shall be designed to prevent personnel from inadvertently interfering with the operation of the weigh system.
4.1.1.2 Careful attention shall be given to foundations, structural supports, piping, and mechanical design to ensure proper operation of the weigh system.

4.1.1.3 Weigh system manufacturer installation instructions and details shall be used in conjunction with safe design practices to ensure that the weigh system operates properly and within accuracy specifications.

4.1.2 System Accuracy

4.1.2.1 General

1. The owner shall furnish the required accuracies for the weigh system.

2. The stated manufacturer’s weigh system accuracies shall be provided to the owner.

3. The live load/gross weight and live load/total weight capacity ratios shall be calculated and provided to the owner to determine if the accuracy specifications are met.

Comment: It is important that the required accuracies are clearly stated. The overall system accuracy is typically lower than the measurement accuracy because load cell accuracy is based on the total weight capacity. Therefore the live load/total weight capacity ratio is important.

4.1.2.2 High Accuracy Systems

1. High-accuracy systems can measure with an accuracy of 0.05% or better for buy-and-sell (custody transfer, or ‘billing’) applications.

2. The weigh vessel shall be fully supported by load transducers.

3. Load transducers shall be supported by an adequately rigid structure.

4. Precision load transducers with full temperature compensation shall be provided.

5. Load transducers shall be protected against heat related damage from heated process vessels.

6. Appropriate horizontal flexible piping and attachments shall be used. Mechanical restrictions from attached piping and lateral restraints shall be avoided.

7. Flexible conduit shall be used to eliminate side forces from reaching the load transducers. Rigid conduit shall not be connected directly to the load transducers.

8. Hot gas and steam-heating systems that can produce variable tare weights shall be avoided if possible.
4.1.3 Load Transducers

4.1.3.1 General

1. Load cells may be used in tension, compression, or bending (load beam) applications.
2. The owner shall specify and approve the type of load transducer and specify if it is to be tension, compression, or load beam.

4.1.3.2 Load Capacity

1. The load capacity of the weigh system shall be calculated to ensure proper sizing of the weigh system equipment.
2. The dead load, live load, and gross weight shall be determined.
3. All structure, equipment, and piping attached to the vessel being measured shall be included in the dead load.

4.1.3.3 Load Transducer Capacity

Load transducer capacity shall be determined in accordance with the following procedure:

a. Estimate the dead load of the system.
b. Determine the maximum live load.
c. Determine the total gross weight of the vessel and attachments.
d. Divide the gross weight by the number of load transducers, and multiply by a factor that is an estimated allowance for low gross weight estimates, unequal load distribution on the load transducers, and for cases where dynamic loads (e.g., vessels weight loaded with crane buckets) may be present.

4.1.4 Excitation/Summing Units

The electronic excitation/summing unit shall be located where easily accessible for maintenance.

4.1.5 Signal-Processing Units

4.1.5.1 The owner shall approve the signal-processing unit.

4.1.5.2 The signal-processing unit shall withstand 100% of gross overload with not greater than 0.1% permanent zero shift.

4.1.5.3 The signal-processing unit shall have not greater than 0.04% of rated output (R.O.) creep.

4.1.5.4 Outputs (e.g., analog, serial, parallel, or bus technology) shall be provided as specified by the owner and within the specified accuracy.

4.1.5.5 The signal-processing unit shall be located with easy access for operation, calibration, and maintenance.

4.1.5.6 The wiring between the excitation/summing unit and the signal-processing unit shall be in accordance with the manufacturer’s recommendation.
4.1.5.7 Printers, indicators, and other external devices shall be specified and approved by the owner.

4.1.6 Weigh Vessel

Comment: The weigh vessel contains the material being weighed. It is important that this vessel be designed, mounted and installed properly to ensure that the weigh system performs within the design specifications.

4.1.6.1 The owner shall approve the structure design and mounting of the weigh vessel.

4.1.6.2 Vessel Mounting

1. The weigh vessel shall be installed so that the force is distributed as evenly as practical to the load transducers.

2. The vessel shall be supported so that it does not tilt or lean when a live load is introduced.

3. Vessels located outside shall be protected from wind, snow, ice, and other unpredictable forces that can add dead load to the weigh system.

4. A shelter shall be considered for a vessel located outside when the weigh system is a high-accuracy system.

5. Where the vessel is insulated and located outdoors, insulation shall be protected from absorbing rain and moisture.

4.1.6.3 Staying and Restraint Systems

1. Staying and restraint systems shall be designed to prevent or reduce disturbances caused by wind, seismic loading, vibration, and other unpredictable forces.

2. Staying and restraint systems shall permit free vertical motion, but limit angular, horizontal, or rotational motion to keep the weigh vessel from moving off its support.

3. Staying and restraint systems shall be considered for all weigh systems that use compression (often referred to as ‘bottle’ type) load cells.

4. Weigh systems that use load beams do not generally require staying or restraint systems.

Comment: Some load beam installations may require staying and restraint if the vessel is extremely tall, such as a silo.

5. Stay rods shall be installed on all vessels that have agitators or vibrators.

6. Stay rods shall be considered an active part of the weigh system and shall be level (horizontal) to ensure linear response with deflection.

7. Check rods shall be considered for extreme cases of high wind. Safety check rods are passive mechanical parts, adding only tare weight to the vessel.
4.1.6.4 Vessel Support Brackets

1. Support brackets shall be designed and located to make the vessel inherently stable.
2. The angular deformations of support brackets shall be less than 0.5 degree under gross weight.
3. Means to jack the vessel to remove or impose load shall be provided to accommodate installation and maintenance of the load transducers.
4. Brackets shall be positioned so that the load transducers are accessible for installation and maintenance.

4.1.6.5 Where hot oil or water may be used for process heating, steam or heated gas shall not be used for a jacketed vessel if possible.

4.1.6.6 For vessels with agitators, the agitator motor shall be mounted on the vessel to provide the most uniform weight distribution to the load transducers.

4.1.6.7 Lifting lugs for calibration purposes shall be considered for vessels that require periodic dead weight calibration.

4.1.7 Structural Design

4.1.7.1 Structural supports and restraint systems shall be provided to stabilize the weigh vessel because unnecessary movement or vibration in weigh vessels may cause inaccurate measurements.

4.1.7.2 The support structure shall be adequately rigid, to avoid cosine errors or other measurement errors.

4.1.7.3 Vessel support structures shall deflect uniformly and not deflect more than 0.5 degree to prevent cosine error from occurring.

4.1.7.4 The vessel plane shall not tilt greater than 0.5 degree from no load to full load.

4.1.7.5 The support structure shall be designed so that inaccurate weight measurements are not caused by varying loads, interaction with adjacent vessels, or movement of interconnected members.

4.1.8 Piping Design

Comment: Piping attached to weigh vessels can cause nonlinearity in the weight measurement.

4.1.8.1 Piping designs shall be arranged so that all loads induced are repeatable, linear, and predictable.

4.1.8.2 All piping connections to vessels supported on load transducers shall be analyzed to determine and correct piping that can add any appreciable or nonrepeatable loads to the cell system.

4.1.8.3 Unless otherwise specified, flexible piping connections shall be used on all connected piping.
4.1.8.4 Piping connections to/from a weigh vessel shall be horizontal. Calculation to determine the effect of flex joint spring constant and deflection shall be performed where any vertical installation is considered and all vertical connections shall be approved by owner.

4.1.8.5 Piping, and related piping support shall be designed to eliminate or reduce lateral, vertical, or rotational loading due to transported fluid temperature changes or drag and elbow redirection forces, including vessel jacket piping.

4.1.8.6 Flex joint support shall be from the off-vessel side (not to vessel or vessel support frame).

4.1.8.7 Sufficient clearance shall be provided around all piping and electrical conduits that connect to a weigh vessel to reduce or eliminate nonlinear mechanical restrictions.

4.1.9 **Electrical Design**

4.1.9.1 All electrical equipment shall be in accordance with electrical area classification.

4.1.9.2 Flexible conduit shall be used at the electrical connection to each load transducer and on any electrical item attached to the weighing vessel.

4.1.9.3 The load transducer cables between transducers and summing box shall be the same length. Excess cable shall be coiled either inside or outside the summing box in accordance with applicable wiring codes.

4.1.9.4 The weigh vessel shall be grounded directly to the structure or grounding grid.

4.1.9.5 Load transducers shall not be in the ground path.

4.1.10 **Calibration**

The owner shall specify the calibration method (e.g., electronic substitution, dead weight, or other method).

4.2 **Continuous Weigh Systems**

4.2.1 Continuous weigh systems shall include loss-in-weight feeders and belt/gravimetric feeders.

4.2.2 Continuous weigh systems shall be purchased as complete units, designed and built by a manufacturer.

4.2.3 The site installation of the equipment shall be in accordance with the manufacturer’s instructions.

4.2.4 The structure, piping, and electrical connections shall be connected to the feeder equipment in accordance with the manufacturer instructions.

4.3 **Weigh Scales**

4.3.1 Weigh scales (e.g., desktop scales, loading dock scales, truck scales, railcar scales) shall be used to measure the weight of a single object.

4.3.2 Weigh scales shall be purchased as complete units.
4.3.3 Weigh scales shall be portable or permanently installed as specified by the owner.

4.3.4 Permanent installation of weigh scales shall be in accordance with the manufacturer’s instructions.

4.4 Calibration and Maintenance

4.4.1 Calibration shall be performed using one of the following methods:
   a. Precise dead weights
   b. Hydraulic means (with calibrated load gauges with accuracy an order greater than the required system accuracy)
   c. Simulated electrical signal only for the purpose of proving all electrical devices. System calibration to prove overall system effective accuracy shall be accomplished either by method a. or b.

4.4.2 The support system and load transducers shall be designed to accommodate the calibration method.

4.4.3 The design and installation of the weight measurement system shall provide ease of calibration and maintenance.