Physical Tank Calibration

Procedures for Volumetric Calibration of Tanks

Physical tank calibration or "wet" calibrating involves the measuring of the actual volumetric capacity of the vessel. This measurement must be precisely correlated to depth so that a pressure/depth/volume table can be generated for the specific tank geometry.

One should consider whether a physical tank calibration is necessary. Tank capacity profiles can be accurately made by King Engineering from the tank manufacturer's drawings and are generally recommended for new tanks.

The cost of a physical calibration can be justified when the application demands greater accuracy. It may also be necessary to calibrate tanks of older vintages since accurate tank drawings are not as readily available.

Important Considerations

Critical to this procedure is the accuracy of the measuring devices employed. While it may seem advantageous to perform the calibration using the actual tank gauging system components, there is a reason why this is not preferred.

If a calibration is based on off-the-shelf system components (especially the sensor), the result will include the unique error characteristics of those components at that time. The data generated will incorporate that unique (and unknown) response characteristic of the primary sensing element.

Should the error band shift or if the component is replaced by another, what had previously compensated for this error would now manifest as a built in error in the tank data. This could (in a worst case situation) be added to the inaccuracy of the new component, resulting in the possibility of an even greater final measurement error.

For this reason, the calibration procedure should attempt to minimize the degree of error. Using known standards with consistent accuracies is the only method by which the degree of error can be controlled during a tank calibration.

Volumetric Standard

A precision volume container or calibrator (calibration can) is recommended. This volume measure should be certified and traceable to NIST (formerly NBS) standards or through state bureau of weights & measures.

Pressure Sensor

The accuracy of the sensor used to detect the hydrostatic pressure created by liquid depth must be precisely known. It is generally good practice to maintain a control sensor as a "de facto" standard whose error band has been documented. This sensor should be carefully handled and periodically checked for accuracy.

Pressure Gauge

The instrument by which the hydrostatic pressure is measured must be extremely accurate - 0.1% of full scale is recommended. The pressure range of any electronic manometer or pressure measurement device should parallel as closely as possible the range of hydrostatic pressure to be measured.

Accuracy vs. Pressure Range

While the accuracy figure of 0.1% is recommended, the resulting error band between a lower range device and that of a higher range can be quite significant. With a range of 0-5 psi, 0.1% FS will equal 0.005 psi or 0.138" of water possible error in measurement. Increase the range to 0-33 psi and that 0.1% FS accuracy now equals 0.03 psi or 0.91" of water as the measurement error. We go from a little over an 1/8" of depth to an error approaching 1" - a nearly 6 times factor.

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Flow Meter

A flow meter can also be used for tank calibrations. However, it should be noted that flow meters are most accurate when flow rates remain relatively constant. In some instances, a throttling valve should be employed to help maintain this constant flow rate.

Generally, water should only be metered out of the tank. This avoids any problems that can occur with fluctuations in supply pressure during tank filling. The changing differential between water supply pressure and backpressure due to increasing depth will cause the effective flow rate to vary. This relationship is difficult to predict if water supply pressure fluctuates during the procedure.

A throttle valve (if used) would be used to gently restrict the flow of water out of the tank when beginning the process. As depth in the tank decreased, the valve could be slowly opened more fully to maintain relatively constant flow. (Because the hydrostatic pressure pushing water out of the tank is reduced as depth decreases, the throttle valve helps to equalize the flow rate.)

It will still be helpful to utilize some type of volumetric standard even when metering is employed. It can be used to prove the meter's functional accuracy. A calibrator or volume standard is especially recommended for measuring the final draw-offs from the tank or for a fill-back procedure.

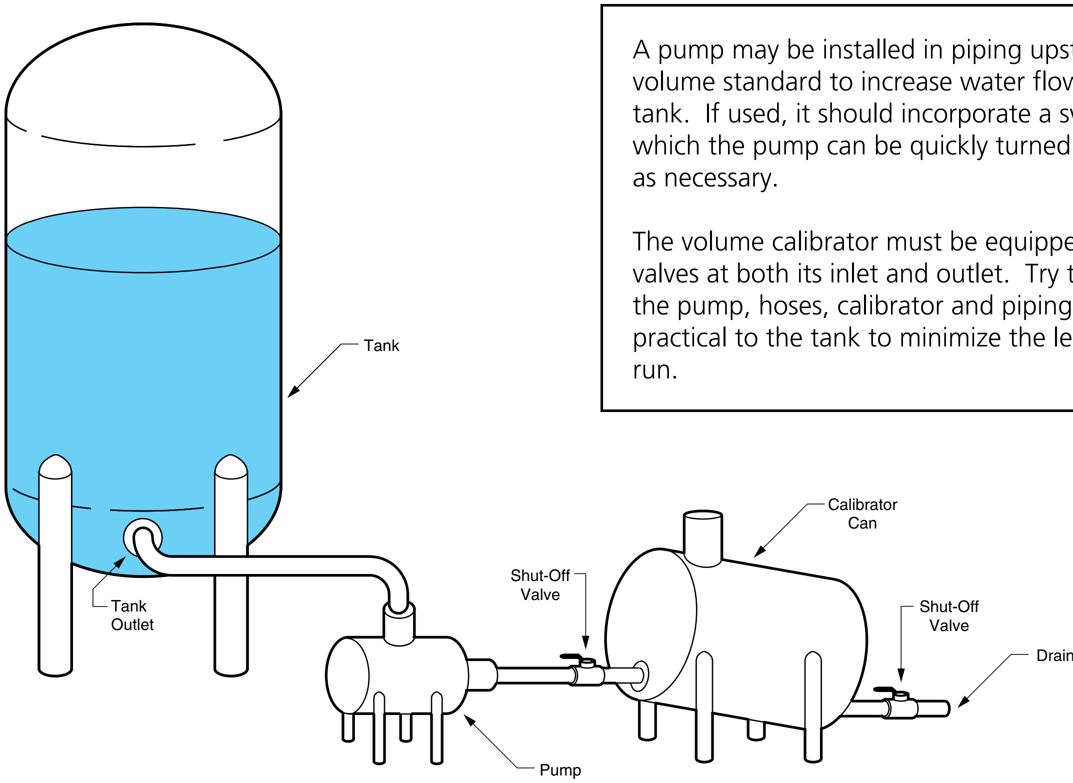
Water Temperature

The volume of most liquids, including water, is dynamic with temperature. Since the objective of the calibration procedure is to determine a precise pressure/depth/volume profile of the tank, the volume must be standardized to temperature. This requires a fairly accurate temperature measurement of the water being used in the calibration process. Temperature should be measured both at the beginning and at the end of the process.

Cool water (40-60°F) is best. **Never use hot water for a tank calibration!**

A pump may be installed in piping upstream of the volume standard to increase water flow from the tank. If used, it should incorporate a switch by which the pump can be quickly turned on and off as necessary.

The volume calibrator must be equipped with valves at both its inlet and outlet. Try to set-up the pump, hoses, calibrator and piping as close as practical to the tank to minimize the length of the run.



Recommended "Out" Calibration Procedure Using Volume Standard (Calibration)

Recommended Calibration Procedure

"Out" Calibration Using AcraSensor, Electronic Pressure Tester and Volume Calibrator

Calibrating proven volume draw-offs out of the tank ("Out" calibration) is a fairly straightforward procedure. Be sure to review the important considerations included in this instruction manual. Attention to detail is the critical aspect of any tank calibration.

Preliminary

Verify the AcraSensor diaphragm response (0.1"-0.2" w.c. error band is acceptable) prior to installation at the tank. This will require a means of measuring any differential between applied pressure and output pressure generated by the AcraSensor/860 Sensor Control.

Using LevelPRO Calibration Mode

"Out" Calibration using electronic sensor/transmitter, KING-GAGE LevelPRO Indicator and Volume Calibrator.

Place the LevelPRO in "Calibration Mode" for this procedure. This will set the display for direct A/D counts corresponding to the 4-20 mA input signal from the transmitter.

Preliminary (Check Zero/Span)

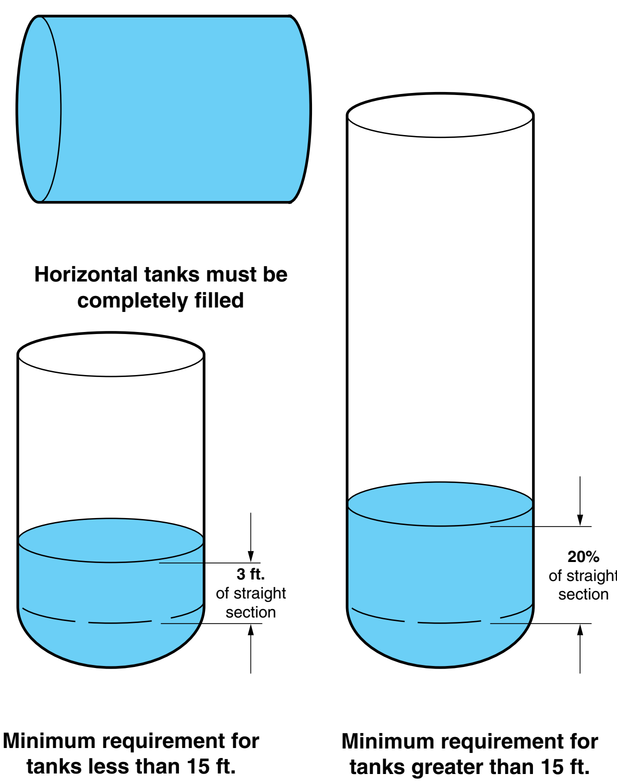
Pressure test sensor prior to installation and make final trim adjustments as necessary to zero and span settings. Be certain to use a high precision multimeter (milliammeter) to measure sensor output.

Basic Procedure:

Use the Calibration Log Sheet EX-1581 or similar format to record calibrator input and associate reading.

- **Vents must be open** and all outlets, manholes, etc. properly sealed. Fill tank with water.
- **Silo Tanks**: filled to at least 20% of the tank's capacity for the calibration
- **Short Vertical Tanks**: at least 3 feet of depth into the straight portion where volume increases remain constant
- **Horizontal Tanks**: must be filled completely to the normally full level

1. Observe and record reading from precision pressure tester with tank filled prior to first draw off.
2. Open inlet valve of calibrator and allow to fill. Close valve as water rises so final level will correspond with level sight.
3. Once the calibrator is full, observe and record reading from a.) precision pressure tester or b.) digital indicator along with corresponding amount of water drawn out of the tank.
4. Repeat the procedure for each draw off. Continue to record each filled calibrator and corresponding pressure/indicator reading.



NOTE: It is generally advisable for one person to be responsible for filling in the log sheet when two or more are involved in the calibration procedure. This will help to ensure consistency in the recording.

5. The last few inches of depth are the most critical in the calibration procedure. As the tank level drops below the sensor, pressure reading should be zero (or will have stopped showing any change in readings).

   Should the final draw off be less than a full calibrator, the exact volume of this partial fill must be carefully measured. Any error in this final amount can result in an error bias throughout the entire calculated tank capacity.

   Electronic Sensor/Transmitter Only: When the tank is empty or it is known that level is below the sensor insertion point, check the sensor's zero output using aprecision meter. If necessary, adjust the sensor zero setting to 4.00 mA prior to the fill-back step that follows.

Fill-Back

To ensure accuracy of the tank reserve, or as verification that can be used to double-check the final partial calibrator draw off, a "fill back" procedure can be employed. After completion of the "out" calibration, the equipment setup is reversed so that the outlet of the calibrator will discharge into the tank. In practice, the fill-back will be made through a nearby manhole, inspection port or other opening.

Starting with a completely empty tank, fill the tank using the calibrator to measure the amount going in. Use enough calibrator fill-backs to generate 3-4 increasing readings.

Extreme care should be used to ensure the accurate accounting of water volume introduced into the tank. Remember to account for the actual volume of water that will be present in the hose itself. This is done by filling the hose line as described in steps 1 and 2 of the following procedure.

Basic Fill-Back Procedure:

The fill-back and associated readings should be specifically noted as IN on the calibration log sheet.

1. Fill the calibrator completely. Open the outlet valve (start pump) and fill the hose line completely, allowing water to flow into the tank, until the calibrator is empty.
2. Close outlet valve and then stop pump so no water can flow back into calibrator. Drain any accumulated water from the tank. The hose line is now filled with the amount of water that will remain as each calibrator load is introduced into the tank.
3. Now proceed to fill the tank using individual calibrator loads until at least 3 or 4 increasing readings are taken.

Calibration Data

The calibration data should reference the name and location of the project. It must identify the following specifics about the tank calibration:

- Whether IN or OUT Calibration
- Calibration Measurement (weight or volume)
- Calibration Standard (volume calibrator, meter, weigh scale)
- Water Temperature
- Datapack Serial No. (if digital indicator used)
- General Tank Description (round vertical, horizontal, etc.)
- Tank Capacity (6000 gal., 10000 gal., etc.)

Important! Submit a COPY of the calibration data log sheet when forwarding the order. A considerable amount of time and money has been invested in the calibration process. The calibration data is therefore quite valuable and should be protected against loss or damage.

Appendix A - Calibration Log Sheet EX-1581

Appendix B - Calibrators (Volume Standard); fabrication plans 30-gallon (S-226) and 100-gallon (S-226-11)

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