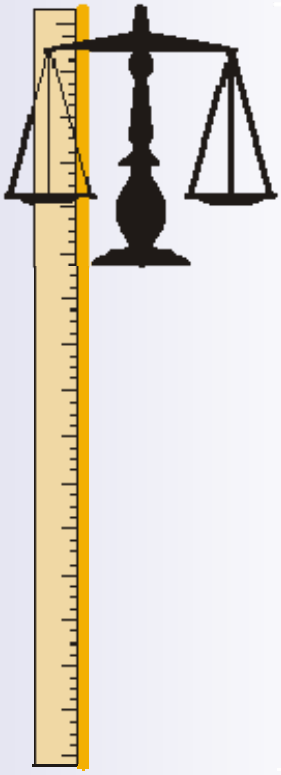
Division of Measurement Standards

Training Module



Six

Field Standards and Test Equipment

Training for the Weights and Measures Official

TRAINING FOR THE WEIGHTS AND MEASURES OFFICIAL

CURRICULUM

MODULE 6 - FIELD STANDARDS AND TEST EQUIPMENT

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Module 2	**-**	**Laws and Regulations**
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Acknowledgment

Developing a training program for weights and measures officials is a challenging and ambitious project. It requires time, dedication, and expertise from many individuals.

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Module Six
Field Standards and Test Equipment

Table of Contents

Introduction

Welcome to "Field Standards and Test Equipment". This is the sixth module in the series "Training for the Weights and Measures Official." It will introduce you to the types of standards and equipment you will use in your profession. It will also explain the appropriate care and use of each.

Completion of this module will not make you completely proficient in the use of all field standards and testing equipment, but it will give you a good foundation on which to build. It will prepare you for "hands on" field training with a qualified county or state official.

At the end of each segment in this module you will find a series of self-evaluation questions to test your knowledge. Although you are not required to complete the self-evaluation, we encourage you to take a few minutes to read the questions before moving on to the next segment. Answers are provided at the end of the module. If you are unsure of a response, reread the training material and it will give you the information you need.

Module Objectives

When you have completed this module you will:

- Be familiar with the standards and equipment you will use.
- Understand which standards and equipment to use for a particular application.
- Know the importance of maintaining and caring for your test standards and equipment.

General Overview

As a weights and measures official, you will be using a variety of standards and equipment to test commercial weighing and measuring devices and products. These include all of the units of weight, volume, length, time, and energy you will use to make a correct determination of the accuracy of devices or products. You will also use equipment to determine pressure and temperature.

The equipment you use daily in the course of your work is designed to provide reliable and accurate standards of measurement while at the same time being rugged enough to withstand the harsh environment sometimes incurred in field testing.

Whenever inspectors discuss equipment, specifications, and tolerances it is almost always related to commercial equipment. Inspectors rarely, if ever, discuss the "tools of their trade". They accept them for what they are and may not fully appreciate what goes into their design, tolerances, and use.

The National Institute of Standards and Technology (NIST) Handbook 44 establishes the design, specifications, and tolerances for commercial equipment.

Inspector's equipment, on the other hand, conforms to a different set of rules. The NIST has issued handbooks known as the 105 series which regulate the standards used by the weights and measures official. Most standards you use will conform to one of these handbooks. They cover a variety of things such as design, materials, construction, markings, and tolerances. The construction of field standards requires the use of suitable materials to ensure the physical properties do not affect the accuracy. For example, using putty to patch up a chipped weight will cause moisture to accumulate in the material resulting in a change in mass of the standard.

The specific documents are referenced throughout this module.

The most common system of measurement in the United States is known as "US Customary", which incorporates units such as gallons, ounces, cubic feet, etc. The metric system or "System International" (SI) is legal in the U.S. and California and you will, on occasion, use metric standards.

Your professionalism and ability to do the work are reflected in how you treat your standards and test equipment. Refrain from using slang expressions such as "bucket" or "can" when referring to volumetric standards or "twenty-fives and fifties" for 25 lb and 50 lb test weights. Use and maintain your equipment as if you care about its integrity. Remember, "properly cared for and maintained equipment is accurate equipment"! Appearance counts!

Each standard you use must have a certificate of accuracy. Obtain a copy of the certificate and carry it with the standard at all times. The accuracy of your standards may be challenged at any time, and it is reassuring to have evidence of their accuracy.

SELF-EVALUATION QUESTIONS

1. What series of handbooks regulate the standards used by weights and measures officials?
2. What types of things do these handbooks cover?
3. How should you not refer to your equipment?
4. How should you use and maintain your equipment?
5. What should you carry with your standards?

Mass (Weight) Standards

As you discovered in ***Module 5 Legal Metrology***, there is a difference between mass and weight. In this module, however, we treat the terms as synonymous and interchangeable with "test weight".

There are several types of mass standards for field use. These vary from weights so small you will use tweezers to pick them up, to weights so heavy specialized lifting equipment is necessary. They range, from ounces or grams, to tons and kilograms. The materials are generally either stainless steel or cast iron although other materials are used, and they come in a variety of shapes: cylindrical, dish, and block.

Weights 5 lb (2 kg) and below often come in kits. The common inspector's "weight kit" normally contains 30 lbs (15 kg) of mass of various sizes and quantity. These would typically be used for small capacity scales and package inspection.

Inspector's Weight Kits

U.S. Kit

Metric Kit

We typically do not use metric weights larger than those in the inspector's field kits as larger capacity scales are rarely metric only and U.S. Customary weights will suffice.

50 lb test weights are often used in groups of ten or twenty giving the official a 500 lb or 1000 lb unit of weight.

Dollies for moving 50 lb weights

Larger weights 500 lb and 1000 lb blocks and above are carried on specially designed vehicles and require the use of assistive moving devices such as weight carts, dollies, or even cranes for weight blocks as large as 2000 lbs.

The material, construction, and tolerances of weights used as field standards are set out in NIST Handbook 105-1.

Materials and Construction

The most common materials for mass standards are stainless steel and cast iron, although other materials are permitted. Brass and laminated weights are not suitable for field enforcement use and may not be used. Brass is too soft for maintaining the required tolerances, and laminated weights are subject to water penetration and possible corrosion. Weights greater than 10 lb/5 kg must have a protective coating; usually lacquer or aluminum paint. Cast iron is permitted for weights 20 lb/10 kg and larger and are color coded; gold for metric and silver for U.S. Customary.

Tolerances

The field standards that you will use are held to Class “F” tolerances, the lowest permitted for weights and measures enforcement. The tolerance is one part in 10,000. For instance, the tolerance on a 1000 lb weight is 0.1 lb (50 g on 500 kg) and 0.005 lb on a 50 lb standard (2 g on 20 kg).

Substitution Weighing

At times, you will find you do not have sufficient certified test weight standards for the capacity of the device under test. This problem can be solved by a method known as substitution weighing. This entails testing the device to the limit of your known certified test weights, noting the indication of the device, removing the standards and replacing or “substituting” them with other material until the device records the same indication as with the standards. The substitution material is now equal in weight to the standards. (The substitution material can be any convenient mass; e.g. a pick-up truck, backhoe, or dumpster, etc.).

Substitution Weighing Using Pick-up Trucks

By adding back the known weight standards to the substitution material, the device is tested to twice the known weight.

For example, you have 12,500 lb in known weight.

- After testing the scale to this amount, note the scale reading, remove the 12,500 lb and add material until the scale reading is the same (this material is then 12,500 lb).

- Add the 12,500 lb of known weights and you now have a test load of 25,000 lb and you have now tested the scale to 25,000 lb. If you repeat the procedure by noting the scale reading and removing this test load, you can substitute material equal to 25,000 lb.

- Add the 25,000 lb test load to the 25,000 lb substitution material and you test the scale to 50,000 lb. Repeat this again and you can reach 100,000 lb.

Handbook 44 restricts this procedure to no more than three substitutions. It is therefore possible, using substitution weighing, to test a high capacity scale such as a 100,000 lb truck scale with only 12,500 lb of known weight or 12-1/2% of the scale capacity providing you have sufficient material for substitution.

Weight Truck Certification

Many counties use their weight trucks as a known test load to permit rapid testing of high capacity scales. This has been the center of much controversy and studies are under way to determine if such use is appropriate.

Certifying the weight of a truck is achieved by using a suitable scale (one with sufficient capacity, sensitivity, repeatability, and section agreement). Known test weights approximately equal to the tare weight of the truck are added to the scale and a reading taken. The test weights are replaced with the truck, the weight of which is adjusted by addition or subtraction of ballast material to replicate the scale reading with the weights. The weight of the loaded truck is this weight plus the weight of any standards placed on the vehicle.

For a detailed description of this procedure refer to Device Enforcement Program Manual EPO 7 Weight Truck Calibration Guidelines.

Weight Carts

500 lb and 1000 lb block weights are usually moved with cranes or dollies. Weights are moved one, two or maybe four, at a time. This can be slow and labor intensive. The use of self-powered weight carts substantially reduces testing time. These electrically or gas powered carts can hold up to 10,000 lb of test weights and are especially useful in conducting the section test on vehicle scales. Initially rejected as invalid non-certifiable standards NIST now has published Handbook 105-8 “draft specifications and tolerances for field standard weight carts”.

Weight Cart

SELF-EVALUATION QUESTIONS

1. What materials are most commonly used for field mass standards?

2. Why do you not find many larger metric weight standards in use in California?

3. Which particular National Institute of Standards and Technology handbook regulates mass standards used by weights and measures officials?

4. What tolerances are applied to field standard weights?

5. What is the procedure by which scales, with capacities greater than your known test weights, can be tested?

Volumetric Field Standards

Volumetric field standards are often referred to by many different terms, usually determined by their size and intended use.

These terms can be somewhat confusing to the new inspector, so in an effort to promote uniformity in terminology, use the following terms when referring to this equipment.

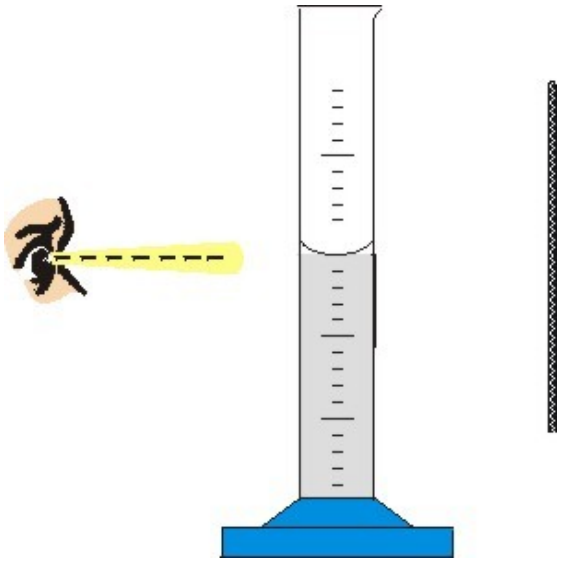
Standard	Refers to all sizes and types of volume standards.
Test Measures	Sizes up to and including 50 liters or 10 gallons.
Provers	Sizes larger than 50 liters or 10 gallons.
Flask, **Measuring Cylinder**, **Graduate**	Generally describe glass measures.
Cubic Measures	Used for measuring dry products**.**

Avoid the use of slang words such as “can” or “bucket”. It shows a lack of appreciation for your standards and does nothing for your professional credibility.

Using the Standards

When using volumetric standards, determining the volume of a liquid product will usually require you to read a meniscus. The surface of a liquid confined in a measuring cylinder curves to form what is known as a meniscus. The meniscus of most liquids curves up the sides of the container due to surface tension, making the center of the curve appear lower than the edges. (Mercury is one of very few exceptions – it curves down at the edges.) Since reading the meniscus at the top or at the bottom of the curve will make a difference in the volume measured, it is generally agreed to always **read the bottom** of the curve. The smaller the container, the greater the curve of the meniscus. Reading a meniscus correctly is a skill that all weights and measures officials must have. Your ability to do this correctly will enhance your confidence in correctly determining volumes.

The correct point at which to read a meniscus is the bottom. Mark a white card with a small black rectangle. Line up your eye horizontally with the bottom of the meniscus. Hold the card behind the measure with the black rectangle slightly below the meniscus. The meniscus appears black against the white card and is readily seen.



Measures that "Contain" or "Deliver"

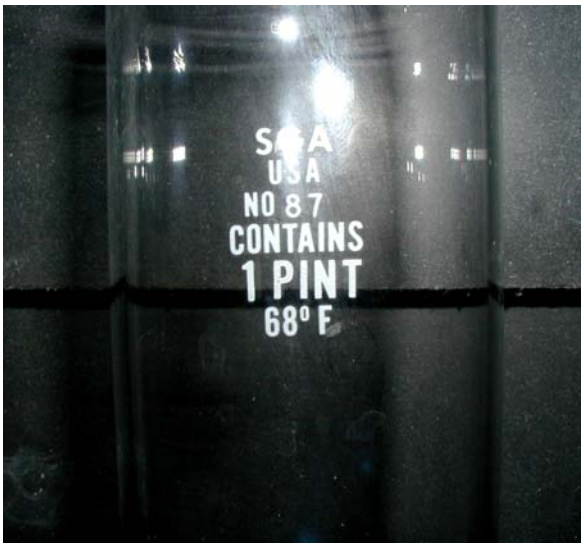
In order to determine the volume of liquid product, inspectors need to have various types and sizes of volumetric measures.

Although there are many different measures for you to use to determine the volume of a liquid, they fall into one of two types. Measures are marked either "to contain" or "to deliver" their nominal volume. These markings are sometimes abbreviated "TC" or "TD". On newer measures, the words "IN" or "EX" appear in place of "to contain" or "to deliver", respectively. The first type allows you to determine the amount of product a measure will hold or contain and the second the amount of product delivered from it. For a measure to deliver its stated volume accurately and consistently, a specific method of emptying and draining must be followed. The full measure is emptied during a period of 30 seconds, tilted to 80 degrees from the horizontal, and allowed to drain for 10 seconds. Drain times are marked on measures and may be different for different measures. Be sure to check. Generally, provers are designed "to deliver" although there are exceptions, notably liquified petroleum gas provers. Test measures and flasks may be manufactured as either "to contain" or "to deliver".

When to Use a "To Deliver" or "To Contain" Standard

There are occasions when a specific volume is required to be delivered from a measure (e.g. 1/2 gallon from a 1/2 gallon flask). More usually though the flasks are used to measure the volume of a liquid poured into them, or to put it another way, measurement is of the liquid "contained" in the flask.

For a "To Contain" flask to accurately measure the liquid "contained", it must be clean and dry. Should the flask need to be reused, it must be cleaned and dried between each measurement. This is because when a liquid is drained from the flask the residue left on the inside surface reduces its volume. If it were not cleaned and dried, the next measurement would be in error by the volume of the residual liquid. A volume of liquid in a standard, that appeared to be say 1/2 gallon, would in fact be short by an amount equal to the volume of the residue; equally, a 1/2 gallon of liquid poured into a wet "to contain" flask would appear to be over-volume by the same amount.



To overcome this problem, we use "To Deliver" flasks which are designed to hold or contain liquid in excess of their nominal volume. This excess is equal to the volume of the residual liquid as described above. Now, if the flask is filled to its nominal volume and emptied it will deliver its stated nominal volume. Each time this flask is used, the same volume of liquid will remain and it will deliver the same volume providing the same drain time is used. The flask in the sample indicates a drain time of 10 seconds.

Now something interesting has happened to this flask. If each time it is used it delivers its nominal volume, and leaves the same residue of liquid, it will only require a volume equal to its nominal volume to refill it. We now have a flask that will "contain" as well as "deliver" its nominal volume, but only after the dry flask has been "wetted down."

As explained earlier, a "to contain" flask cannot be used "to deliver" but a "to deliver" flask also becomes "to contain". Therefore, it is preferable to use "to deliver" flasks which can be used both ways.

Wetting Down or Conditioning a "To Deliver" Standard

"To deliver" standards are manufactured to hold more liquid than their stated volume. When using a "to deliver" standard you must first "condition" it. This is done by filling the standard, in most cases, with water and emptying it using a specific technique. Once full, slowly empty the standard during a period of 30 seconds, tilting it to 80 degrees from the horizontal and allow it to drain for 10 seconds. The water clinging to the inside of the standard reduces its volume to the stated volume. The standard is calibrated to be correct in this "wetted down" condition. Now when product under test is poured in, the standard can accurately determine its volume. The standard can be washed out between tests and reused without drying, providing you use the specific technique described above. For some products, the "wetting down" procedure is done using the product under test to prevent contamination with water. Provers with bottom drains or pumps are not inverted to empty them and the timing is limited to the drain period marked on them.

Draining Flask

Types of Volumetric Standards

Volume standards come in many shapes and forms; flasks, graduates, burettes, pipettes, small hand carried provers, large vehicle mounted provers, large static provers, LPG provers, bell provers, cubic measures, and pycnometers (density cups).

Volume standards fulfill two distinct functions when measuring liquids: determining the accuracy of a device dispensing product or the accuracy of the statement of fill in a packaged product. Although many measures can perform both functions most are designed for specific tasks.

Glassware, Graduates and Flasks

For checking the quantity statements on packaged products, the most common standards used are glass graduates or flasks ranging from 2 fl oz (50 ml) to 1 gal (4 L). National Institute of Standards and Technology (NIST) Handbook 105-2 discusses these standards. They may only be made of transparent borosilicate glass (the type of glass sold under the trade names Pyrex or Kimax). This material is chosen because it has a very low coefficient of expansion, and permits their use without the need for temperature correction when used in the field. It is also fairly resilient and resistant to mild knocks.

When smaller volumes are needed, pipettes and burettes are also used. These standards are normally carried as a set in a purpose-made carrying case for convenience and protection of the glassware.

Glassware

Hand-Carried Test Measures

By far the most common hand-carried test measure you will use is the five-gallon test measure for checking retail gasoline or diesel dispensers. NIST Handbook 105-3 gives the details of this standard.

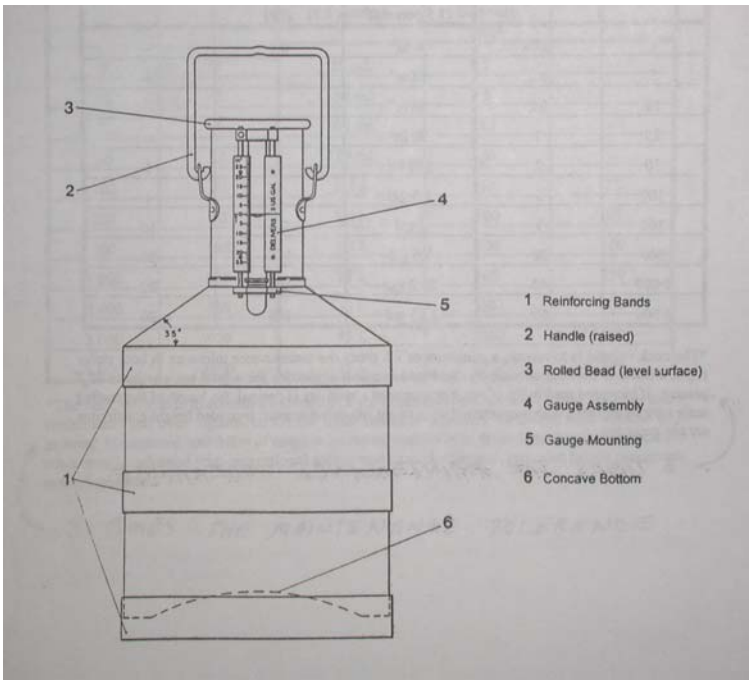
Five-Gallon Test Measure

These test measures are available in several sizes:

1, 5 and 10 gallon (5, 20 and 50 liter)

They are generally made of low carbon steel. Its low cost and durability make it a most suitable material. Stainless steel, due to its rigidity and corrosion resistance, is preferred for those standards, but its high cost and weight precludes its use for all but the most precise measurement operations.

The handbook is very specific on the shape and construction of these standards and a thorough reading of the text of Handbook 105-3 would be necessary to cover them all.



5 Gallon Standard

These standards are circular in cross section and reinforced to prevent distortion when full or when being transported. This normally takes the form of reinforcing bands on the sides. The bottom is made concave to prevent distortion when full and has a protecting band, which also provides a stable and level support.

The handle on a test measure is attached to the neck rather than the body or shoulder to minimize distortion when lifted full of liquid.

A graduated scale plate is provided next to or behind the gauge tube to permit measurement of liquid level above, below or at the zero indication mark; and for a 5 gallon test measure the scale markings generally go from minus 25 in^3 to plus 25 in^3.

The scale plates are marked either “Contains” or “Delivers” or “IN” or “EX”.

As mentioned earlier, for the work we do, we use “To Deliver” test measures.

In addition, each standard has the following information permanently attached:

- Name and address of manufacturer
- Model number
- Non-repetitive serial number
- Material identification
- Material thickness
- Coefficient of cubical expansion
- Nominal volume
- Drain time

Vehicle Mounted Five Gallon Standards

With the ever-increasing size of service stations and the number of dispensers at a single location, efforts have been made to improve the efficiency of testing. One way of doing this is mounting bottom drain provers in a vehicle fitted with holding tanks. When the provers are emptied the fuel drains or is pumped into the tanks. This eliminates the time taken to return the product to the storage tank when the standard is hand carried and is less tiring for the official.

5 Gallon Prover, Bottom Dump

Prover Truck

Provers

These larger volume standards, because of their size and weight, are either static or vehicle mounted.

4 Vehicle Mounted Provers

50 Gallon Prover

Specialized Provers

Liquefied Petroleum Gas (LPG) Prover

This prover is designed to hold petroleum gas under pressure so it can be measured in a liquid state.

LPG Prover

Bell Prover

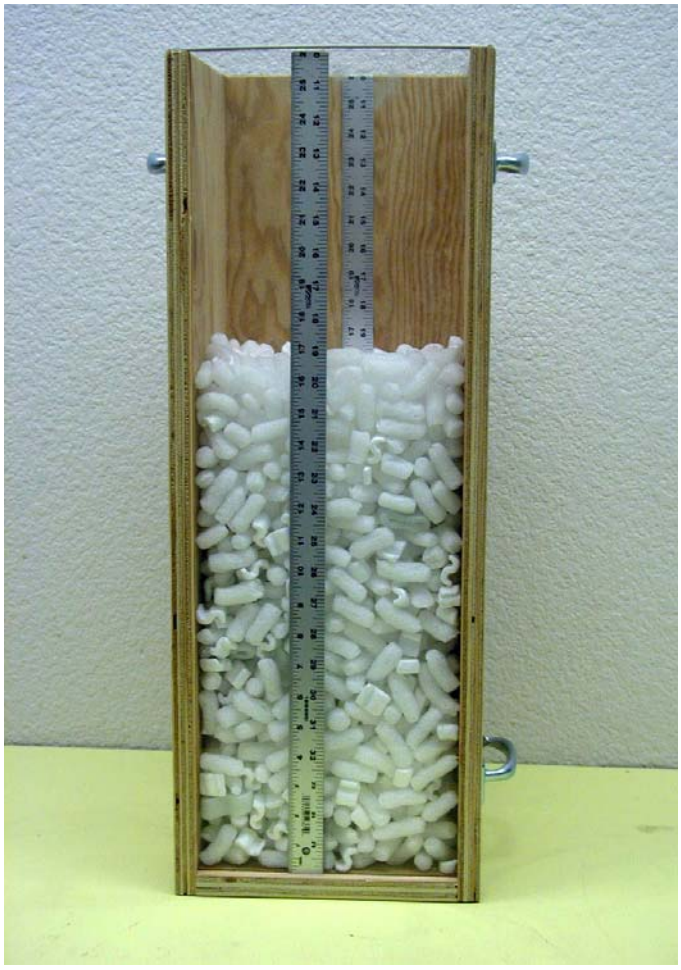
This prover is a specialized type of prover that measures the volume of air passing through a vapor meter. The sizes generally in use in county labs are either 2 or 5 cubic feet capacity. These provers must be maintained and used in a temperature controlled environment.

Photo of Bell Prover

Cubic Measures

To determine the quantity of dry products you will use a variety of measures known as cubic measures. These generally follow a rectangular box pattern with an open top and can be constructed of wood, metal, or plastic. Sizes are convenient intervals between 1 cu ft and 1 cu yd or the metric equivalents. Some may have clear sides and graduations similar to a glass graduate, but most define the quantity by the top edge. Quantity determinations are made by filling the measure and using a straight edge to screed off the excess product.

Dry Measure

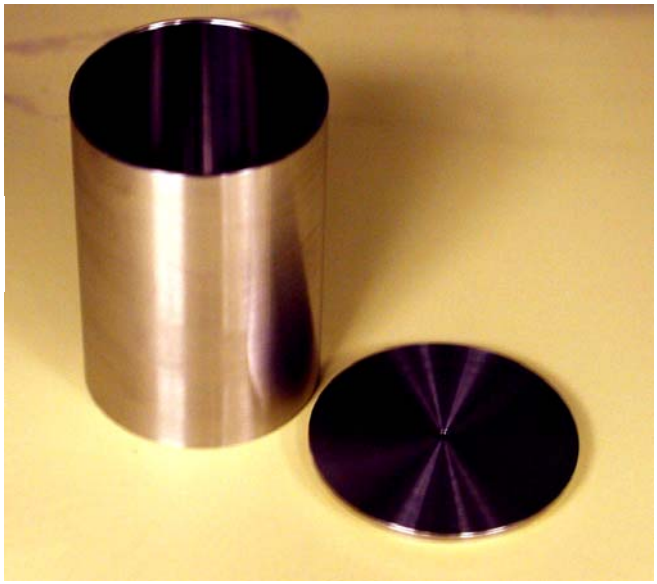


Pycnometers (Density Cups)

This is a container of precise volume, which is used to determine product density. The volume of viscous fluids is difficult to verify using the volumetric standards already discussed. An alternative method is to determine the product density using a pyconmeter, weigh the product, and using its density, calculate the volume.

Pycnometer

Density Cup



SELF-EVALUATION QUESTIONS

1. When we use the term “standard” in context with volumetric measures, to what are we referring?

2. What is a meniscus?

3. Do you read a meniscus at the top or bottom?

4. What do the terms “IN” and “EX” on a measure indicate?

5. A “to contain” measure must be wet or dry before use?

6. When conditioning a “to deliver” measure what are the usual emptying and drain times?

7. Which particular National Institute of Standards and Technology handbook regulates glass graduates or flasks used by weights and measures officials?

8. Which specialized prover must be maintained and used in a temperature controlled environment?

Length Standards

Standards of length can take many forms: tapes, rulers, calipers, micrometers, depth gauges, pre-measured distances, etc.

Linear Measuring Tapes and Rules

Linear measuring tapes are generally made of flexible metal and are available in a variety of lengths typically 25 ft to 100 ft. The smaller pocket tapes (6 ft to 25 ft) frequently used by officials may not have been certified. Be sure to check. For shorter distances, rigid measures such as rulers and graduated straight edges are used. Special fabric tapes, graduated in yard increments and made of soft non-stretching material, are available to test fabric-measuring devices.

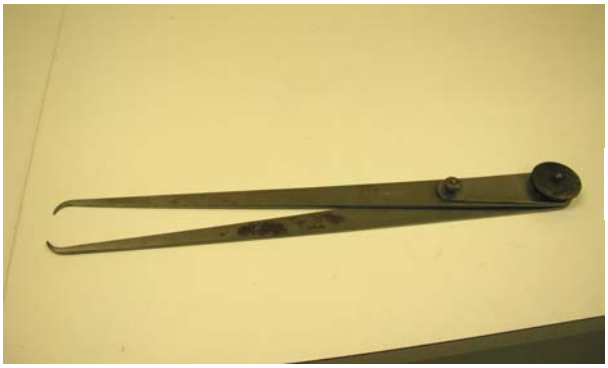
Linear measures are available with the foot increments divided into tenths instead of inches. Known as decimal tapes or measures, these are very useful when you calculate area or volume.

Micrometers

A micrometer is an instrument for measuring small distances, usually the thickness of an item up to about 1/2 inch. It operates by rotating a finely threaded screw against a small flat surface.

Calipers

A Caliper is an instrument consisting of two hinged legs, either straight or curved, used to measure internal and/or external dimensions. A variation is a caliper rule which is a graduated rule with one stationary and one sliding jaw.

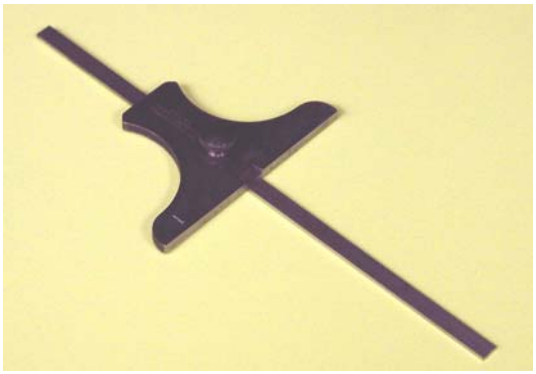


Caliper

Caliper Rule

Depth Gauges

These devices read the level of liquid in a container. In its simplest form the gauge is a graduated rule held perpendicular to the surface of the liquid to determine the distance of the liquid level from the top of the container. A specific use would be to determine the level of product fill in paint cans.



Distance Simulators

These devices are used in testing taximeters for accuracy. A taxicab's wheels rest on and drive large rollers that rotate to simulate a given distance to which the taximeter is compared. The slang term "rolling road" is sometimes used.

Taxi Under Test

Rollers of a "Rolling Road"

Pre Measured Distances

Another distance measuring method is the “measured mile”, a distance on a road that is physically measured using a certified length measure and marked on the road surface or a fixed marker beside the road. This distance is used to calibrate another distance measuring device known as a “fifth” wheel, described next.

Taximeter Start

Taximeter Finish

Fifth Wheels

Fifth wheels are distance-measuring devices consisting of a wheel and counter normally attached to the bumper of a test vehicle and towed for a specific number of revolutions of the wheel. This is then compared to the distance metered by the taximeter under test. The “fifth wheel“ is calibrated using a “measured mile” and adjusted by changing the air pressure in the tire. They are subject to inaccuracies from such things as inaccurate tire pressure and “bouncing”. With the advent of moulded integral bumpers, attaching the “fifth wheel” to a vehicle posed difficulties and they are no longer in general use.

Fifth Wheel

SELF-EVALUATION QUESTIONS

1. What is a decimal tape?
2. Are the legs on a caliper straight or curved?
3. Give a specific use for a depth gauge.
4. How is a “measured mile” determined?
5. What is a “rolling road” and what is it used for?
6. Why are “fifth wheels” no longer used?

Time, Temperature and Electricity

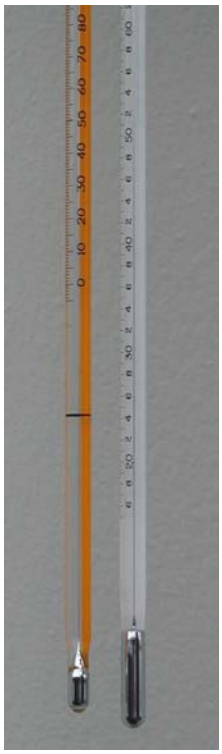
Stopwatches

These are used in a variety of applications as a standard or as a supplement to other test standards. They are used to determine the accuracy of timing devices such as taximeters, coin operated laundry machines, parking meters, etc. They are also used to verify flow rates when testing volume-measuring devices.

Thermometers

There are two principal types of thermometers you will encounter in your work, the conventional mercury-in-glass and electronic thermometers.

Mercury-in-Glass - You should be aware that mercury-in-glass thermometers can be total-immersion or partial-immersion. Total-immersion thermometers are designed to be read at the medium's surface. To indicate temperature correctly, the liquid being measured must cover the mercury column. Partial-immersion thermometers have a mark or line for the immersion depth near the first graduation. A total immersion type has no such mark or line. Total immersion thermometers produce more accurate readings when used correctly. Be sure you know the type of thermometer you are using and use it correctly.



Total and Partial Immersion Thermometers

Electronic - Electronic thermometers may have analog or digital readouts, but by far the most common are digital. The type of sensor used determines accuracy, temperature range, and cost.

Thermocouples are among the easiest temperature sensors to use. They are widely applied in science and industry. They are based on the Seeback effect that occurs in electrical conductors that experience a temperature gradient along their length.

A thermistor thermometer uses a solid semiconductor that converts changes in resistance, due to changes in temperature, to a readout calibrated in temperature units. They exhibit great sensitivity and accuracy in the 32°F to 212°F range.

Resistance Temperature Detectors (RTD) are among the most precise temperature sensors commercially used and are stable and repeatable over a wide temperature range. They are based on the positive temperature coefficient of electrical resistance.

Electronic Thermometers

Electric Meter Watt-Hour Standard

The standard consists of a high precision watt-hour meter together with a variety of high precision resistors to simulate various electrical loads. It is used for testing utility electric meters for accuracy.

Watt-Hour Standards

SELF-EVALUATION QUESTIONS

1. What are the two principal types of thermometers?

2. Which produce temperature readings that are more accurate: partial-immersion or total-immersion mercury-in-glass thermometers?

3. What are the most precise temperature sensors commercially used?

4. What does an electric meter watt-hour standard consist of?

Other Equipment

Weighing Devices

There are various types, sizes and capacities of weighing devices used in weights and measures field work: balances, equal arm, single pan, electronic, platform and, on occasions, vehicle scales.

The Metrology Program probably has the greatest use for balances and other weighing devices, but for the field official, the most common use is for package inspection. For products up to about 60 lb (30 kg), we generally use portable digital electronic balances. These are convenient, accurate, and reliable. They also have the capability of capturing weight data and transferring it to appropriate software for calculation.

Electronic Balance

Before digital electronic scales were in common use, equal arm balances were used to verify net content of packages. They require the use of weights from the inspector's weight kit to determine package weights. They are fast, accurate and reliable. They are still valid for use as a package checking scale and many officials keep these devices as a backup to electronic scales.

Equal Arm Balance

For larger items portable platform scales with capacities 1000+ lb are available. Some of the electronic models are powered by vehicle batteries for field use.

Platform Scale

Commercial Scales

Although it is preferable to use your own equipment, it is sometimes necessary to use commercial scales for enforcement purposes. This is acceptable provided certain precautionary measures are taken. It is vital that the device is suitable and operating correctly (adequate resolution, sensitivity, no binds). Accuracy of the scale, while highly desirable, is not absolutely essential. Remember, it is your weights that are the standards against which you are comparing accuracy of weight statements and the scale is used only as a comparator.

If a scale does not have the accuracy you require, use the substitution method with your standards to replicate the weight you are trying to verify. For example, if you are checking the weight of 70 lb sacks of cement on a commercial platform scale that is working fine, except it is inaccurate at the range you need to use it, you can still perform the test.

- First, gross weigh the sack and take a reading. Replicate this reading with your standards.
- Determine the tare weight. You will probably have a suitable accurate scale to do this.
- Calculate the gross weight of a correctly filled sack; labeled weight 70 lb, plus the tare weight, is say 70.45 lb.
- Place 70.45 lb of standards on the scale and take a reading. The scale may read 70.55 lb but do not worry, this is the zero point for the correct gross weight.
- Add standards in values equal to the resolution of the scale say 0.05 lb, to an amount you believe the sacks may be over-packed.
- Record the scale reading for each weight value and you now have a correction table for the plus errors.

It is easier and quicker than it sounds. Now weigh the sacks in your sample. For over-packed sacks you use the correction table for the error, and for any underweight sacks add standards until the scale reads the correct gross weight. The standards used are the minus errors. This is not as swift as using an accurate scale but certainly doable.

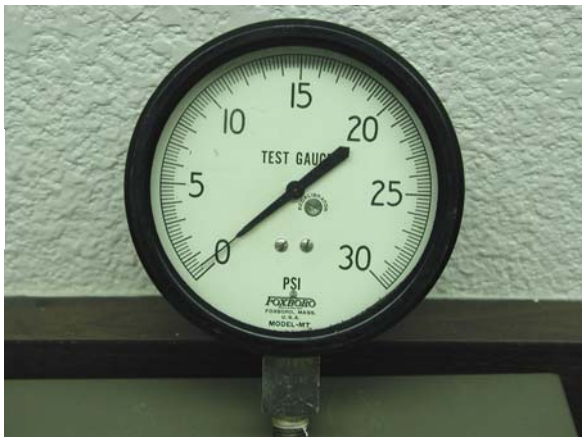
Pressure Gauges

The volume of a gas changes inversely in proportion to pressure applied at a constant temperature. Increase pressure, volume decreases and vice versa. This follows the principle described in Boyles Law and is shown by the equation

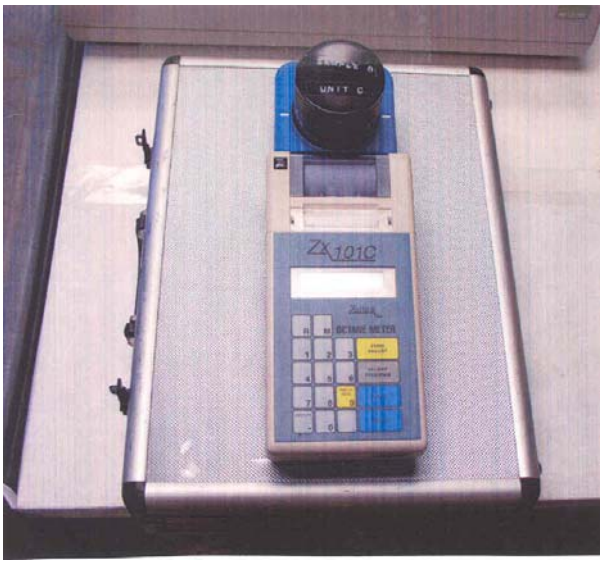
$$\text{Volume} = \frac{\text{Temperature}}{\text{Pressure}}$$

When checking the volume of vapor delivered by a device or contained in a package or cylinder, the measurement is made at a specific reference temperature and pressure. A pressure gauge determines actual gas pressure for any pressure corrections needed to calculate volume corrections.

Pressure Gauge



Zeltec® Octane Analyzer



This device screens gasoline samples in the field to determine octane rating. It is calibrated with fuels with known octane.

You must be aware that this does not give official readings, but only identifies suspect samples. The results **can not** be used to remove the product from sale or require reposting of the octane number.

Trap Tanks

For undercover checks on the accuracy of volume dispensers, vehicles are fitted with false tanks which use the fill pipe of the vehicle's original fuel tanks. Purchased fuel is dispensed into the false tank and later measured using certified measures. Some tanks have been connected to a weighing device. Knowing the weight of the fuel delivered and its density, the official can determine if the correct volume was delivered. In addition the purchased fuel can be tested for quality without disclosure.

Undercover Trap Tank Mounted in Division of Measurement Standards Vehicle

Hidden Provers

These are similar to the false tanks described above except these provers can directly determine the accuracy of a delivery.

Water Finding Paste

Water finding paste detects the presence of water in fuels by changing color when it encounters this fuel contaminant. One method is to smear the paste on a storage tank dipstick and then dip it into the fuel. The presence of water in the fuel causes the paste to change to a specific color.

RFI/EMI Producing Equipment

The operation or performance of devices must not be affected by radio frequency or electromagnetic interference.

When inspecting electronic devices, one of the tests you will perform will be to operate various radio emitting devices such as CB and two-way radios and cellular phones near the device. The device should not be affected.

Radios and Cell Phones

Levels

Most standards must be level to ensure proper reading of indications. Attached level bubbles, if present, are sometimes dirty, broken or are just not functioning correctly. If this is the case, you will then have to use a level gauge horizontally against the sight glass.

Prover with Attached Levels

Level Gauge Against Sight Glass

Vapor Recovery Nozzle Tester

In the late 1970's, the vapor from the nozzles of gasoline dispensers was mandated to be reduced. The recovery systems devised to control gasoline vapors from the nozzles did so by sucking the vapor back into the storage tank during delivery into a vehicle. A device called a vapor recovery nozzle tester that simulates a vehicle gasoline tank is used to determine if only vapor and not liquid is being returned to the storage tank.

Vapor Recovery

SELF-EVALUATION QUESTIONS

1. What type of balance was commonly used for package inspection before the advent of digital electronic balances?
2. Can you use commercial equipment for enforcement purposes?
3. If a scale is inaccurate does that mean you cannot use it?
4. What equipment could you use to field test the octane rating of a gasoline sample?
5. In addition to checking the accuracy of volume dispensers what other benefit is there to using hidden trap tanks?
6. Give an example of when you would use water finding paste.
7. What does a vapor recovery nozzle tester simulate?

Tools and Safety Gear

When testing devices such as electric meters, LPG meters, and heavy capacity scales, specialized equipment and clothing become a necessity. Also, when working with chemicals and contaminates that could be hazardous to an inspector, proper procedures and attire are paramount. You will receive more information on safety equipment and procedures when you receive field training from Division Specialists. Also be sure to carry a first aid kit!

Care of Equipment

When not in actual use, keep and transport standards in their containers. Where a suitable container is not provided for a particular piece of equipment, secure it in a vehicle in such a manner as to prevent damage.

50 lb weights pose a special risk and should be secured in the vehicle.

Exercise care when using equipment, not only to preserve its integrity, but also to promote public confidence in you and your standards.

Cleanliness of the equipment is an important part of this confidence. Dirty, battered test measures; greasy, stained weights; dirty glassware; dried product on scale platters; and worn-out weight boxes and containers do nothing to enhance the credibility of the inspector or his/her equipment.

Remember, you will be judged by the appearance of your equipment and how you use it!

Glass Kit

SELF-EVALUATION QUESTIONS

1. How should you store standards when not in use?
2. Why should you exercise care when using equipment?
3. What does your equipment say about you?

GLOSSARY

A LISTING OF TERMINOLOGY AND ACRONYMS MOST COMMONLY USED BY WEIGHTS AND MEASURES OFFICIALS.

Bell Prover - Device used to measure the volume of air passing through a vapor meter. It is kept and used in a temperature controlled environment.

Cubic Measure - Used to measure volume of dry products.

Fifth Wheel - Device consisting of a wheel and counter attached to the bumper of a vehicle and used to test taximeters.

Flask - Alternate name for glass measure.

Graduate - Alternate name for glass measure.

Measuring Cylinder - Alternate name for glass measure.

Meniscus - Curved surface of a liquid in a measuring cylinder.

NIST - National Institute of Standards and Technology.

Prover - Volume standard larger than 50 L or 10 gal.

Pycnometer - Container of precise volume used to determine product density.

Substitution Weighing - Procedure by which scales, with capacities greater than available known test weights, can be tested.

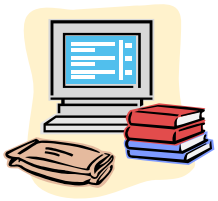
Test Measure - Volume standard up to and including 50 L or 10 gal.

Test Weight - Synonymous with mass standard.

Weight Carts - Self powered carts that hold up to 10,000 lb of test weights; used in the testing of large capacity scales.

Weight Dolly - Moving device for weights, often hand operated.

Zeltec® Octane Analyzer - Commercial name of device capable of field determination of octane rating of gasoline.



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SELF-EVALUATION ANSWERS

Segment 1

1. National Institute of Standards and Technology Handbook 105 series.
2. Design, materials, construction, markings and tolerances of standards.
3. Do not use slang terms and expressions.
4. Use and maintain equipment as if you care about its integrity.
5. A copy of the certificate of accuracy.

Segment 2

1. Stainless steel and cast iron, although other materials are used.
2. Larger capacity scales are rarely metric only and U.S. Customary weights will suffice.
3. National Institute of Standards and Technology Handbook 105-1.
4. “F” class tolerances.
5. Substitution weighing.

Segment 3

1. All sizes and types of volume standards.
2. Curved surface of a liquid contained in a measuring cylinder.
3. Bottom.
4. “To Contain” and “To Deliver”, respectively.
5. Dry.
6. 30 and 10 seconds.
7. National Institute of Standards and Technology Handbook 105-3.
8. Bell prover.

SELF-EVALUATION ANSWERS

Segment 4

1. A linear measure with the foot increments divided into tenths.
2. They can be either.
3. Determining the level of product fill in paint cans.
4. Physically measured using a certified length measure.
5. A slang term for a distance simulator used to test taximeters.
6. They are subject to inaccuracies from inaccurate tire pressure and bouncing. Modern integral bumpers posed attachment problems.

Segment 5

1. Conventional mercury-in-glass and electronic.
2. Total-immersion mercury-in-glass thermometers if used correctly.
3. Resistance temperature detectors (RTD). They are also stable and repeatable over a wide temperature range.
4. A high precision watt-hour meter together with a variety of high precision resistors to simulate various electrical loads.

Segment 6

1. Equal arm balances and field standard weights.
2. Yes, provided you take certain precautionary measures.
3. No, you can use it as a comparator; the weights are the standard against which you are comparing accuracy of weight statements.
4. A Zeltec® octane analyzer.
5. Purchased fuel can be tested for quality without disclosure.
6. On the end of a dipstick to detect water contamination in fuel.
7. A vehicle gasoline tank.

SELF-EVALUATION ANSWERS

Segment 7

1. When not in use keep and transport standards in their containers or secure them to prevent damage.
2. To preserve its integrity and promote public confidence in you and your standards.
3. You will be judged by the appearance of your equipment and how you use it.

We would appreciate your taking a few moments to complete our training evaluation feedback form. We welcome your comments and any suggestions you might have regarding Training Module 6. You may E-mail your response to us at DMS@cdfa.ca.gov or mail to Division of Measurement Standards at 6790 Florin Perkins Road, Suite 100, Sacramento CA 95828-1812.

1. Did this module fulfill your expectations?

2. What did you like/dislike about this module?

3. What areas would you like to see improved?

4. What specific changes, if any, would you recommend?

5. How could this module be better organized to make it easier to follow and learn from?

6. Was this module too basic or too advanced for someone with an entry level background in weights and measures?

7. Additional comments or suggestions.