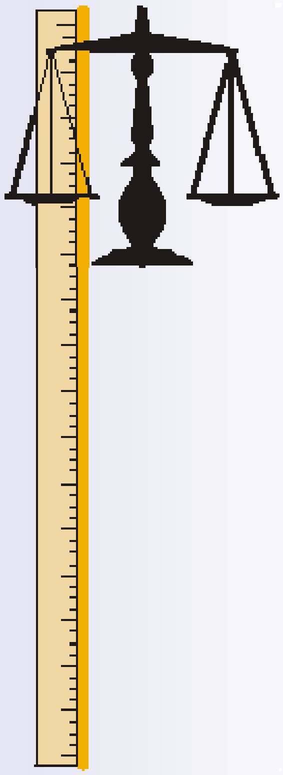
Division of Measurement Standards

Training Module



Ten

Measuring Devices

Training for the
Weights and Measures Official

TRAINING FOR THE WEIGHTS AND MEASURES OFFICIAL

CURRICULUM

MODULE 10 - MEASURING DEVICES

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.

It is impossible to list the names of the many people who contributed to the development of this course. However, gratitude is extended to the following groups whose dedication and commitment made this training module a reality.

Module Team

Paul Jordan—Team Leader
Richard Cano
Bob Doyle
Norm Ingram
Greg Mukai
Dan Reiswig

Editing Team

Dennis Johannes
David Lazier
Roger Macey

Production Team

Carol Allen
Angie Averitt

Module Ten
Measuring Devices

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Introduction

Welcome to "Measuring Devices". This is the tenth module in the series "Training for the Weights and Measures Official". It will introduce you to the proper steps in determining if a particular type of measuring device is suitable for its application, is installed properly, is accurate, and is being used correctly. Throughout this module you will learn the various terms, definitions, and enforcement tools a field inspector uses in the testing of the myriad measuring devices and their components. Completion of this module will not completely qualify you to start testing devices on your own, but it will give you a good foundation upon which you can build. It will prepare you for "hands on" field training with a qualified County or State inspector.

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 able to:

- Understand the difference between commercial and non-commercial, the importance of the type-approval process, and the progression of authority from the Secretary of the Department of Food and Agriculture to the field inspector.

- Know the reference tools such as the California Code of Regulations and the Device Enforcement Procedure Manual (formerly known as the Examination Procedures Outline) and how to use those tools in the enforcement of rules and regulations as they apply to measuring device testing and use.

- Understand the various types of measuring devices, their application and use with the different commodities.

- Understand the effects of temperature and pressure on certain commodities and how some measuring devices compensate for these variables.

Introduction to Measuring Devices

What do time, water and electricity have in common? How can the distance between two locations and the power to run an electric motor be related?

The answer is actually quite simple and is the same for all of these examples. Time, water, electric power and the distance between two or more locations are all commodities that have a value: a monetary value and a measured value.

- When we step into a taxi, the distance that we travel costs us based on how far we ride or how much time we spend in traffic.
- The utility companies charge us based on the amount of electricity, water, or natural gas we use at our home or place of work.
- Municipalities collect money from the timed parking meters.

Since the time that humans began to barter items and services, some form of mutually agreed upon unit of measurement must have been established. Before the creation of measuring machinery, items would be measured by the amount of liquid placed in an urn or measured by comparing against the length of an arm or the distance of a stride.

General Requirements

The California Code of Regulations is the body of rules that gives the specific requirements for devices. When a device is used for commercial purposes it must undergo a type approval process. This process is used to establish that the mechanism maintains accuracy and functions properly under normal working conditions and does not facilitate fraud.

What is being said when the term “commercial purposes” is used? All devices can be divided into two types: commercial and non-commercial. As weights and measures officials, we concern ourselves with the commercial variety. “Commercial devices” are used in the determination of the charge for a commodity or service. So, any device that weighs, counts, or measures a commodity or a service for which a customer is charged is considered “commercial”. Some of these devices are scales, taximeters, timing devices, and a variety of liquid-measuring mechanisms.

An example of non-commercial devices would be the use of a metering device in a processing plant. The device measures portions of materials that are combined to make a final product, a carbonated soda for example.

A universal requirement for devices is identification. Regardless of the type of device or what it measures, weighs or counts it must have uniform identification. The manufacturer’s name or trademark, along with a model designation that positively identifies the design or pattern of the device, is mandated. A non-repeating serial number is also required, unless the device has no moving or electronic parts. For devices that have been type approved, a National Type Evaluation Program Certificate of Conformance number shall be displayed (non-retroactive as of January 2003).

All measuring equipment, mechanisms and devices shall be constructed in such a manner that, under normal use, they will maintain their accuracy. All of the parts and adjustments will remain in working order. These measuring mechanisms need to be constructed in such a way that they do not enable the perpetration of fraudulent use. When devices are installed, they must be suitable for the environment in which they are being used and suitable for the product being measured. This includes the device’s ability to properly deliver the product (e.g., flow rate, size of piping, indicating elements, etc.). Measuring device installations shall be to the manufacturer’s instructions. If the installation causes instability in the measuring results, then the way it is installed must be redesigned or possibly the equipment is not appropriate for that particular use. Wind, weather and even, radio frequency interference (RFI), caused by electronic devices, shall not affect devices.

The identification plate with all the required information, must be readily observable. The device needs to be accessible for the testing equipment. The device should be located so testing equipment can properly function. It is the responsibility of the device owner to supply any special facility, transportation and labor needed to inspect, test and seal their measuring devices. Because of the nature of some devices, testing often takes place at a centralized location (e.g. County Weights and Measures testing lab). Bringing devices to a central location for testing is commonly used for safety purposes (e.g., electric meters, natural gas vapor meters) or efficiency (e.g., water meters).

The owner or operator must use their device in the method for which it was designed. All associated equipment must meet all of the performance requirements (tolerances). If the devices are used in direct sales, the primary indicating element (the mechanical index or electronic readout) shall be located so it can be read from a reasonable customer and operator position. After testing, a security seal shall be affixed to the adjustment mechanism.

Regulations affecting devices are of two types:

Retroactive Requirements	Non-retroactive Requirements
Enforceable to *all* equipment The requirements affect all of the devices already produced and to be produced.	**Apply *only* to those devices produced after the effective date of the regulation** On the effective date a regulation takes place, it applies only to those affected devices that are manufactured or imported into the State on or after that date, or to devices being placed into commercial service for the first time.

SELF-EVALUATION QUESTIONS

1. What is a commercial device?

2. What are three requirements found on the identification plate of a measuring device?

3. What is the difference between retroactive and non-retroactive regulations?

4. Name three uses of commercial type devices.

Types of Measuring Devices

This module is segregated into segments reflecting various types of measuring devices. Commodities can be sold, and therefore measured, not only as liquids, but gases, time or even solids.

Before the advent of scales, nearly all commodities were measured by volume. Originally, units of measure were the amounts a person could hold in their hand or carry. But as civilization grew and trade was initiated between different people, standardization of units of measure was required. In Egypt, the initial unit of measure for liquid and grains was the ***Ro***, which was about a mouthful. The Egyptians used the ***Ro*** as a base unit of measure. Larger and smaller quantities could be measured by doubling or halving it.

In Mesopotamia different sized buckets, made of iron, were used as standards against which merchants' standards could be compared.

These devices were simple and effective. Now, what does this have to do with modern day measures? We shall see.

Linear Measuring Devices

Linear measuring devices are types of equipment that measure length and distance.

Units of Divisions

Decimal	Division into tenths; this includes the metric system.
Duodecimal	Division into twelfths; used by the Romans (example, 12-inch foot).
Binary	Divides a unit of measure into halves.
Sexagesimal	Division into 60 parts, used by Babylonians (example, time and circles).

Measurements are practical activities and people express measurement in practical ways. Early measurements demonstrate this:

> ***Stadion*** is the distance a person could run before getting winded (approximately 200 meters),
>
> ***Furlong*** is the distance a horse could pull a plough without stopping for a rest,
>
> ***Acre*** is the amount of land two yoked oxen can plough in one day.

The Egyptians used the four fingers called a palm, later a hand, for measuring small distances. Similarly, the cubit, the distance from the end of the forefinger to the elbow was a common measure used in building.

All of these measurements are linear measures. The devices used for linear measure, for the most part, can be rather simple. Even so, today's linear measuring devices have some very specific requirements. They can fold or flex, but they can not be made of cloth! Why not, you might ask yourself? Linear measuring devices cannot be made of cloth because cloth stretches. Once it has stretched the measure is no longer accurate. You will have noticed, if the linear measuring device end is softer than brass, that end must be protected by a metal tip that is as hard as brass or harder. Why is this you ask? Wooden yardsticks are frequently used common linear measures. After measuring a commodity with a yardstick, the item like cloth or rope is then cut. If the end of the wooden yardstick is not protected, it becomes quite possible to whittle away the end. So after some time of use, the yardstick is no longer 36 inches in length.

Speaking of measuring cloth, there are specific machines used to measure cloth. These devices are not as common as they once were. They are mechanisms that have rollers under spring tension. These rollers, through meshed gears move the measuring indicator. How the meter works is the cloth is placed between the rollers, and then manually pulled through the rollers causing the gears to turn, the indication to change, and the cloth's length to be measured. Again, these measuring machines are used less often. One reason is they are more expensive and complicated than a ruler or yardstick. Cloth is commonly sold by the yard or binary subdivision of a yard. Actually, you will find that metal yardsticks are the cloth-measuring devices of choice in many cloth shops.

Odometers

Another commercial linear measuring device that is extremely common is the automobile's odometer. Mileage service charges are computed from the readings of the odometer. Ambulances, rental cars and towing trucks are examples of services charged over an odometer.

Odometers work in two different ways: mechanical and electronic. Mechanical odometers have a wire-type shaft that connects to either the transmission or a wheel. As the transmission or wheel turns, the shaft turns and causes the meshed gearing in the odometer to register the distance traveled. The electronic odometer uses a pulse counter on the transmission. As the transmission turns, it causes a device to create an electronic "pulse" which is counted. A certain number of pulses translate to a measured distance. These pulses are then transferred to the digital readout on the vehicle's dashboard and relayed as distance traveled. Obviously, changing the size of the tire or the gear ratios of the transmission will affect the accuracy of the odometer. Because tire size affects the accuracy of the odometer, consistent tire pressure is important. The air pressure in the tire can affect the size of the tire. Too high amount of pressure and the tire becomes oversized, too little pressure and the tire becomes undersized. It is important the tire is inflated to the manufacturer's recommended pressure level.

Measure-Containers

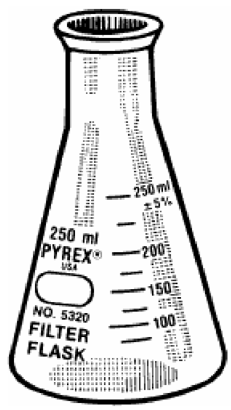
These are containers, including lids or closures, and generally, are only used once. The capacity of the containers shall be in multiples of or binary submultiples of, a quart or a liter. The capacity point shall be sharply defined by the top edge, a line near the top edge, or the horizontal cross-sectional plane that is established by the bottom surface of the removable lid.

Containers need to be designed in some suitable geometrical shapes. The shape and its construction material must not allow distortion of its capacity.

Graduates

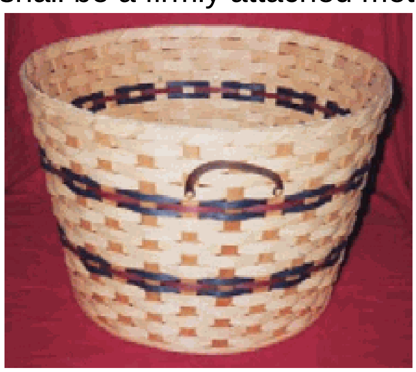
Graduates are designed to measure liquids. A graduate is designed to be filled to a designated line or to the top of the container. It can be either a straight-sided cylinder or a circular cone. The base must be perpendicular to the vertical axis. The calibrated graduation must be perpendicular to the vertical axis of the graduate. Graduates are allowed to have single-scale or double-scale graduations.

Graduates shall be made of a clear, thoroughly annealed, transparent glass that is free of bubbles and streaks. Any flaws in the glass could affect the accuracy of the measurement. A graduate can be designed "to deliver", or "to contain" a certain volume of liquid, when the temperature of the liquid is at 20°C (68°F). The difference between the two types is that a "to deliver" graduate takes into account the small bit of liquid that clings to the side of the graduate. As an example, a "to deliver" one gallon graduate actually contains enough liquid to equal one gallon when poured out plus the amount of liquid clinging to the walls of the graduate. The "to contain" graduate holds exactly one gallon of liquid.



Dry Measures

These are rigid measures, designed for repeated use in the measurement of solids. They are not used as shipping containers. These containers can be made of any suitably strong material that will retain its shape during normal usage. The top edge of these measures shall be reinforced. If the measure is wooden, other than a basket, the reinforcement shall be a firmly attached metal band.



The shape of the dry measures must be either cylindrical or conical in shape. The bottom of the container shall be flat, except for metal bottom, which can be slightly corrugated and perpendicular to the vertical axis. The bottoms of dry measures shall not be adjustable or movable. Dry measures can be either watertight or non-watertight. The capacity of a measure shall be determined by the top edge of the measure. Capacities shall be in one bushel, multiples of a bushel, or binary submultiples of a bushel.

Berry Baskets and Boxes

These measuring devices are for berries and small fruits in capacities of one dry quart and less. Construction, like those of dry measures, can be of any suitable materials, provided they retain their shape and capacity during any normal filling, storage and handling. The capacities of berry baskets or boxes shall be in 1/2 dry pint, 1 dry pint or 1 dry quart.

SELF-EVALUATION QUESTIONS

1. What is linear measure?

2. Why must the ends of a yardstick be as hard as brass or harder?

3. Could a ruler or tape measure be made of rubber? If not, why not?

4. What does an odometer do?

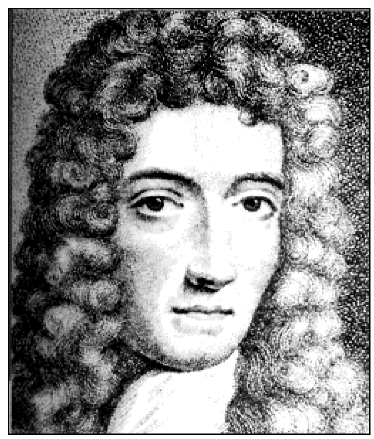
5. How are measure-containers used?

Liquid Measuring Devices

Before we proceed, let us cover some important issues concerning the effects of temperature and pressure on gases and liquids.

Temperature: Both liquids and gases respond to varying temperature in a similar way except gases respond to a greater extent. As the temperature of a gaseous or liquid product increases, the volume of the product increases. Conversely, as temperature decreases the liquid or gas contracts. Because of this fact, the volume measurements for many gases and liquids are referenced to a specific temperature, such as 68°F/20°C. Corrections are made mathematically using coefficients of cubic expansion. When testing liquid and gas meters officials must be aware of this principal.

Pressure: The effect of pressure on liquids is negligible for the pressures we normally encounter and can be disregarded, but on gases it is of great concern for accurate measurement. Boyles Law: 17th century scientist Robert Boyle determined that the volume of a gas varies inversely in proportion to the pressure on it provided the temperature remains constant. As pressure increases volume decreases.



Robert Boyle

Other concepts to remember are:

Mass - The mass of a product is the amount of matter contained in the substance.

Weight - The weight of a product is the force acting upon it due to the gravitational attraction of the earth.

Density **-** Is the measure of mass in a given volume (density = mass/volume)

Liquid measuring devices come in a variety of designs, for a variety of liquids. Water meters can be a simple single brass or plastic body with a mechanical dial as an indicator or a remote electronic indicator can be added. Gasoline and diesel dispensers can be fully electronic or like the water meter have a mechanical indicator and computing part. These meters can vary in their rate of flow, slower flows for filling automobiles with a vapor-recovering system or a faster flow delivering fuel in large quantities. ***Module 7 Basic Weighing and Measuring Principles*** contains the working methods of how the various types of devices measure liquid. Here we will study the variety of liquids and how their characteristics affect measurement and the requirements placed on devices that measure liquid.

When your time comes to delve into the California Code of Regulations you will see a section called Liquid Measuring Devices [3.30]. This section deals only with liquids such as fuels, fertilizers and other agricultural-chemicals, but does not include propane, water and mass-flow type meters and some others. For the purpose of discussion in this module, these sections have been combined.

According to Funk and Wagnall's New Encyclopedia:

> ***Liquid*** - Means substances "in an intermediate state between the gaseous and solid states. The molecules of liquids are not as tightly packed as those of solids or as loosely arranged as those of gases. Under appropriate temperature and pressure conditions, most substances are able to exist in the liquid state. Densities of liquids are usually lower than, but close to, the densities of the same substance in the solid state."

Liquid-Measuring Devices - Are mechanisms "or machines designed to measure and deliver liquid by definite volume. Means may or may not be provided to indicate automatically, for one of a series of unit prices, the total money value of the liquid measured, or to make deliveries corresponding to specific money values at a definite unit price."

The liquids that are measured can dramatically vary in temperature and pressure. Gasoline that is stored in underground tanks will be at the ambient ground temperature, commonly about 50°F to 60°F. Propane is a gas liquefied under pressure and must be contained in a high-pressure vessel in order to maintain its liquid state, but it will be gaseous at normal ambient temperature and pressure. Cryogenic liquids (liquefied oxygen, argon, and nitrogen) are an example of an extreme temperature liquid, having a boiling point less than -243°F (120° Kelvin). But their pressures are usually low, about 12 to 15 psia at temperatures below their boiling point. Even though liquid characteristics have wide variations, the devices that measure them have much in common.

Cryogenic Meter

Regardless of the liquid variety, all liquid-measuring devices have primary indication elements. The one exception is the water dispenser that delivers a pre-set amount, so no digital or analog indicator is required. Liquids can be measured in an abundant choice of units of measures: pints, quarts, liters, gallons, pounds, kilograms, and cubic meters or cubic feet. Meters, also, can measure or record in fractions or decimal submultiples of the previous units. Primary indicators must be readily returned to a zero indication prior to dispensing more liquid. As an example, when purchasing gasoline the dispenser will automatically return to zero if it is electronic or it must be manually reset prior to a new delivery if it is a mechanical analog dispenser.

Retail Gasoline Dispenser

After liquid passes through the measuring device there shall be no means to divert it from the discharge line. So once liquid is measured, it must be delivered to the purchasing customer. Another mechanism employed to maintain the accuracy of delivery of the measured liquid is the vapor eliminator. Displacement and turbine-type meters cannot tell the difference between liquid or gaseous vapor in its measuring chamber or measuring unit, potentially allowing vapor to be measured with liquid. If this situation occurs, the customer will be paying for unusable vapor at the same rate as the liquid being purchased.

Another aspect of liquid-measuring devices is the type of delivery hose. One type of hose is the wet-hose. Wet-hoses are designed to operate with the discharge hose full of liquid at all times. An added piece of equipment that helps the hoses remain wet is the anti-drain valve. In a pressure-type wet-hose device the anti-drain valve is placed adjacent to the discharge valve. The anti-drain valve functions so as to prevent drainage of the discharge hose.

The other type of delivery hose is the dry-hose. A dry-hose is a discharge hose intended to be completely drained at the end of each delivery of liquid.

All liquid-measuring devices require the liquid in the measuring chamber to be maintained in a liquid state. This can be a particular problem with liquefied gases, where temperature or pressure changes in the measuring chamber can cause the liquid to vaporize creating bubbles.

Propane Meter

Another factor pertaining to obtaining accurate delivery of liquids is temperature compensation. Temperature compensating mechanisms are required on liquified petroleum gas (propane) metering systems that have a flow rate of over 20 gallons (100 liters) per minute, and are optional on other liquid devices. The temperature compensating mechanism must determine the temperature either in the measuring chamber or adjacent to the meter inlet or discharge line. Temperature compensating systems for petroleum products usually correct the delivered volume to 60°F (15°C).

Temperature Compensator

As with all measuring and weighing devices, they must be equipped with a way to seal any adjustable or replaceable part that affects the metrological function of the device. Audit trails are also an acceptable means for tracking and keeping fraudulent adjustments of the device from occurring.

Security Seal

For retail devices (except slow-flow meters) if a liquid measuring device is equipped or designed with an ability to compute a price per volume, unique features are required. In the event of power loss, the information needed to complete any transaction in progress shall be determinable for at least 15 minutes at the dispenser or at the console, if the console is accessible to the customer.

A computing retail device must compute the total sales price at any single-purchased unit price. When the delivery is completed, the total price and quantity dispensed shall be displayed for a time period of at least 5 minutes or until the next transaction begins.

A-1 Gas
1234 High Street
Carlton, CA 00009

- -

DATE:	12/30/02
TIME:	10:14:49 am
SHIFT:	0
CLERK:	13131313
REGISTER:	
TRANSACTION:	32942

---REPRINT RECEIPT---

QTY	DESCRIPTION	PRICE	TOTAL
10.169	**G Regular**	**1.399**	**14.23**
	10.169 Items Sold	SUBTOTAL	14.23
		AMOUNT DUE	14.23

Receipts shall be made available through a built-in or separate recording element for all transactions conducted with a debit, credit card or cash transaction. The printed or written receipt needs to have the total volume; the unit price per volume and, of course, the total computed price. The receipt must also have the name or symbol of the product purchased.

Why are these items required on the receipt? All of this information is necessary so that the customer has an accurate record of what was purchased, how much was purchased and the total value of the purchase.

SELF-EVALUATION QUESTIONS

1. What does Boyle's Law say about the relationship between the volume and pressure of a gas at constant temperature?

2. What is the difference between mass and weight?

3. What is a cryogenic liquid?

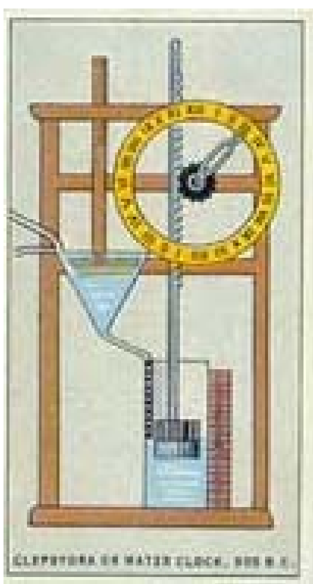
4. What is the purpose of an anti-drain valve?

5. Give an example of a liquid measuring device that requires temperature compensation.

Timing Devices

Time cannot be placed on a scale, held in a container, or measured with a ruler. But much of commerce deals with time. Most working people are paid by the hour, so telling time accurately is of the utmost importance, and not just for commercial purposes.

The way time was initially measured was keeping records of the repetition of natural events, like the sun's passage through the sky forming the day. The cycle of the moon equals a month. The length of a day was fixed by the rotation of the earth on its axis, even though at different times of the year the length of the day appears to vary. The differing lengths of darkness and light cause this variance in appearance. What we call an hour is just a one-twenty-fourth part of an average solar day. This twenty-four hour day is an arbitrary subdivision, not following any natural time divisions.



The Babylonians created the divisions of an hour into 60 minutes and a minute into 60 seconds. They used a water clock. This clock dripped water from one jar into another jar through a carefully calculated hole. The amount of time it takes for the water to completely drip from one jar to the next was the length of one day. The accuracy of the device was not improved upon for several thousand years. Today, though, we have not only mechanical clocks but also electronic digital devices.

These devices can determine how long the drying cycle is at a laundromat or how long an automobile has been parked in one parking stall. And some commodities, such as drinking water, are dispensed not through a water-metering device but rather an accurate timing device, combined with a constant pump pressure.

Taximeters

There is a metering device that combines both a linear measuring component and a timing factor. This is the taximeter. Taximeters have two elements of measuring combined with a calculator.

- First the taximeter measures distance. This distance measuring component divides a mile into fractions, such as tenths or eighths of a mile. Whatever units of distance the taximeter uses; there is a corresponding charge for that unit of distance. For example, the taximeters may be set up to charge $0.20 for each one-tenth of a mile. This charged unit of distance is referred to as a **Drop.** It originally came from the dropping of the flag on the old style meters.

- The second component of the taximeter is the timing factor. The timing portion of the taximeter divides these waiting periods or non-movement periods into blocks of time and charges a given amount of money for each block of time. As an example, the taximeter may charge $0.20 for every 20 seconds on non-movement time. It is actually a little more complicated than this example.

There is a point of slow movement that both the timing and distance portions of the taximeter are working. Generally, as the vehicle exceeds about 11 to 13 miles per hour the timing device is deactivated.

After a taxi driver picks up a client, the taximeter is activated. As the taxi moves, the odometer portion of the meter registers the distance. This is accomplished by an electronic or mechanical wire attachment to a wheel or transmission, like the odometer. The calculating portion of the taximeter will compute the amount charged to a customer based on the amount of distance units traveled (i.e., the number of one-tenths of a mile traveled). Because the measuring instrument is attached to the transmission or directly to the tire, tire size is an important factor. The circumference of the tire is a set distance at a set air pressure. As air pressure varies so does the circumference of the tire. Think of a rubber balloon, as more air is put into the balloon it stretches, so does a rubber tire. As the tire stretches the circumference increases, as air is let out of the tire its circumference decreases.

As the taxi is slowed or stopped by traffic or road conditions, a timing device will take over. When the taxi arrives at its destination, the computation aspect of the taximeter will combine the total costs of distance traveled and the cost of the time involved and give a total cost of the transportation.

It is important to know that California laws require taxis to have posted the rates used. This requirement allows the customers using the taxi to know how much they are going to be charged.

Electric Watt-Hour Meters

Unlike other commodities, that are measured and sold by quantities such as length, weight, or volume, electricity is a substance without physical shape or weight. What, then, is electricity? Simply put it is the flow of electrons along a conductor. The common conductor we are dealing with is a wire. We will discuss four elements that make up the measurement of electricity.

Amperes (amps) is simply the measure of the rate of flow of electrical current or electron movement. It is the quantity of current caused to flow by a difference of potential of one volt through a resistance of one Ohm (or Amps = Volts/Ohms).

Ohm is a practical unit of electrical resistance. Resistance is opposition to the flow of current in a circuit. Resistance can be defined with the formula Ohms = Volts/Amps.

Voltage (volt) is electrical pressure that causes an electron flow in a circuit. Since voltage is a unit of electrical pressure, it is always measured across two points. A volt meter is the instrument used to measure the voltage value.

Watt is a practical unit of active power and is defined as the rate at which energy is delivered to a circuit. It is the power expended when a direct current of one Ampere flows through a resistance of one ohm (or Watts = Volts x Amps).

To understand more about energy, it is important to distinguish between energy and another common factor – power. **Power** is the rate at which an electrical circuit performs work. It is expressed in units called watts, or more commonly, in thousands of watts or kilowatts. On the other hand, **energy** is power multiplied by time. Thus, if the power in a circuit is two kilowatts, and this power is used for three hours, the total energy consumed is 2 kilowatts x 3 hours = 6 kilowatt-hours. Consumption of electrical energy is measured by a watt-hour meter and indicated in kilowatt-hours, so that the utility can bill the consumer at so many cents per kilowatt-hour.

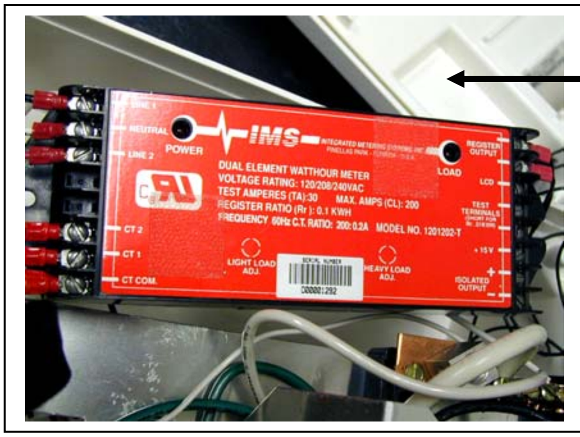
Oversight of the sale of electricity from public utilities and the accuracy of meters used is for the most part, left to the Public Utilities Commission (PUC). However, where electricity is resold in a submetering environment, the PUC does not regulate the activity and California weights and measures officials have jurisdiction. Submetering occurs in places such as apartment complexes and mobile home parks where individual meters owned by the property owner are installed on the water, gas, or electric supply line for billing individual unit's usage. You will recall that we adopt by reference the latest version of National Institute of Standards and Technology Handbook 44 as the basis of our regulations governing the inspection and testing of weighing and measuring devices. As we are one of the few jurisdictions nationwide that regulate electric watt-hour submeters, the handbook does not have a code that addresses these meters. California has therefore developed regulations based on industry standards to inspect and test electric watt-hour meters.

Using meters to determine a charge for electricity is not new. One of the first was developed by Edison. In 1882 he developed a chemical ampere-hour meter that consisted of a jar holding two zinc plates connected across a shunt in the customer's circuit. Each month the electrodes were weighed and the customer's bill determined from the change in their weight. So you can see even from the start, weights and measures has been involved in the measurement of electricity.

The rotor type of meter that was developed in the 1890's has been the standard up until recently. This worked by using a disk whose speed of rotation varied with the amount of electricity being used. The rotating disk was connected to a series of dials calibrated in kilowatt hours.

Type J3A A-Base Meter

In recent years, solid-state electronic watt-hour meters have been developed and as the technology improved they have gained acceptance with users.



Electronic Meter With Led Indicator

These meters do not have a rotor or disk but operate by sensing the applied load and load current on a given circuit. Measurement is done electronically.

SELF-EVALUATION QUESTIONS

1. Originally, how was the unit of time based?
2. How is time a commodity?
3. When a taximeter distance is divided into eighths or tenths of a mile, what are they called?
4. What measuring components make up a taximeter?
5. What effect does tire pressure have on a taximeter?
6. What is the difference between power and energy?

Computer Software and Audit Trails

Software

This segment explains the requirements when computer software is interfaced with measuring devices.

Some commercial devices are strictly mechanical in operation, some devices are strictly electronic without moving parts, and some may be a combination of the two. All devices require sealing of their metrological (accuracy affecting) components. This could be a physical seal or electronic seal.

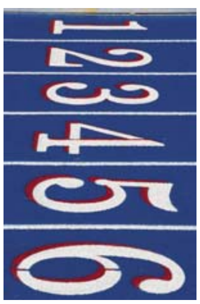
Computer software is used in the measurement process for devices such as retail motor fuel dispensers, electronic cash registers, liquefied petroleum gas meters, electric meters, and taxi meters just to name a few. When software is used in the measurement process, it must be evaluated with the device in which it is to be used (see ***Module 8 - Device Type Evaluation***). This could be a single device or multiple devices containing software that make up a system.

One example is a turbine meter measuring element connected to a pulser. The measuring element of the turbine meter and pulser combined generate a signal.

Turbine blades are moved by the liquid flow. As the blades pass by an electronic pickup sensor, the pulses are counted. Pulses equate to turbine revolutions which equate to specific volume. The signal is processed by the computer processor which is where the metrological software resides. The software used to interpret the signal is adjustable and affects the accuracy of the measurement process. The terminology used for this software is called calibration and configuration parameters and is considered a part of the metrological portion of the device and is required to be sealed. Some examples of calibration and configuration parameters are meter factors, measurement units, temperature compensation tables, flow control settings, octane blend settings, and specific gravity.

Besides the use in the measurement process, software is used for tracking the changes made to the calibration and configuration parameters. The tracking of these changes is called an "Audit Trail". Audit trails are always electronic and can be viewed on the device's indicators or computer screen.

Audit Trails



This section explains the requirements of audit trails and where to find information on Audit Trails. Audit trails exist only in electronic devices or mechanical devices connected to a computer or electronic display that can affect calibration.

Audit trails have been accepted since 1989. California Code of Regulations, Section 1.10., G-S.8., allows for the provision of sealing adjustable electronic components. Audit trails (software) provide more information than a lead-and-wire seal and are a tool for the weights and measures official to determine if any changes have been made to the adjustable parameters.

An audit trail is an electronic count and/or information record of the changes to the values of the calibration or configuration parameters of a device. This record may be viewed or printed to determine if any changes have been made. A device or system may have a physical seal, audit trail, or combination of both. Certificates of approval contain information on how to access the audit trail information for a particular device or system.

Where to Find Audit Trail Requirement Information

The California Code of Regulations, Handbook 44, and Publication 14, contain specific information on audit trail requirements. Publication 14 is a checklist of test procedures for evaluating weighing and measuring devices and includes detailed audit trail criteria. Handbook 44 and Publication 14 are available through the National Conference on Weights and Measures.

As new technology is introduced, audit trail criteria are amended to help ensure fraud does not go undetected whether accidental or intentional.

SELF-EVALUATION QUESTIONS

1. What is an audit trail?

2. What types of devices would have an audit trail?

GLOSSARY

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

Absolute Pressure – In the U.S. Customary system, pressure is measured in pounds per square inch; in the international usage it is kilograms per square centimeter. Absolute pressure is defined in relation to a specific known pressure of one atmosphere (atm) of 14.696 pounds per square inch or 1.03323 kilograms per square centimeters.

Audit Trail – An audit trail is an electronic tracking of the changes that have taken place in the calibration and configuration parameters.

Boiling Point – Temperature at which a product changes to a vapor.

Cryogenic Liquid – Is an extreme temperature liquid whose boiling point is lower than -243°F (120° Kelvin)

Gauge Pressure – Most pressure gauges record the difference between the pressure of the liquid or gas in a container and local ambient atmospheric pressure.

Linear Measure – The measure of length. A plain ruler or a meter stick gives you a linear measure.

PSI – Pounds per square inch.

PSIA – Pounds per square inch absolute.

Pressure – The force per unit area exerted by a liquid or gas on a body or surface, with the force acting at right angles to the surface uniformly in all directions.

Submetering – Submetering occurs in places such as apartment complexes and mobile home parks where individual meters owned by the property owner are installed on the water, gas, or electric supply line for billing individual unit's usage.

Volume – The measure of the space occupied by anything.

BIBLIOGRAPHY AND REFERENCES

California Code of Regulations

How Much & How Many; Jeanne Berdick, Franklin Watts Publisher

Man the Measurer: Our Units of Measure and How They Grew; Roy A. Gallant; Double Day and Co.

National Institute of Standards and Technology Handbook 44

National Institute of Standards and Technology Publication 14

Yardstick of the Universe; Owen Bishop, Peter Bedrich Books

SELF-EVALUATION ANSWERS

Segment 1

1. Commercial devices are used to determine a charge for a commodity of service.

2. Manufacturer's name, model number, and non-repetitive serial number.

3. Retroactive applies to all devices regardless of date of manufacture. Non-retroactive applies to devices manufactured on or after an effective date, imported into the State or a non-commercial device being placed into commercial service.

4. Electric meter, water meter, water dispenser, gasoline dispenser, taximeter, grocery store scales (hanging, counter or computer scales), etc.

Segment 2

1. Linear measure is the measure of length or distance.

2. If the end of the wooden yardstick is not protected, it becomes possible to whittle away the end. So after some time of use, the yardstick is no longer 36 inches in length.

3. No, a ruler or tape measure could not be made of rubber, because rubber stretches, thereby making it inaccurate.

4. An odometer measures mileage in a vehicle, and can be used to charge customers for the distance traveled.

5. The product to be measured is placed in the container, to a known edge or line producing an accurate measurement.

SELF-EVALUATION ANSWERS

Segment 3

1. Boyle's Law states that the volume of a gas varies inversely in proportion to the pressure on it provided the temperature remains constant.

2. Mass of a product is the quantity of the substance; the amount of matter contained in a given volume, such as 1 gram per milliliter. Weight of a product is the force acting upon it due to the gravitational attraction of the earth.

3. Cryogenic liquid is an extreme temperature liquid whose boiling point is lower than -243°F (120° Kelvin)

4. Anti-drain valves keeps liquid from running out of a pressure-type wet hose.

5. Liquid petroleum gas metering systems with flow rates greater than 30 gallons (100 liters) per minute and mass flow meters.

Segment 4

1. Time was originally based on natural events, such as the sun's passage through the sky.

2. Time is a commodity because we can buy things by units of time. Examples could be hiring a person to work for us by the hour, or buying a certain amount of time in a clothes dryer.

3. The increments that taximeter measures, such as eighths or tenths of a mile are called drops.

4. The register, a time and distance calculating portion and either a wire attached to the wheel or transmission on a mechanical taximeter or a pulse counter attached to the wheel or transmission for an electronic taximeter.

5. Tire pressure affects the size of the tire. An under-inflated tire is smaller than the manufacturer's specification and an over-inflated tire is larger. The circumference of the tire affects how many revolutions it makes over a certain distance traveled thereby affecting the accuracy of the measuring elements in the taximeter.

SELF-EVALUATION ANSWERS

Segment 5

1. An audit trail is an electronic tracking of the changes that have taken place in the calibration and configuration parameters.

2. The devices must have an electronic display or be connected to a computer. Examples of devices that would use an audit trail tracking software are many, including retail motor fuel dispensers, electronic cash register, taxi meters, etc.

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 10. 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.