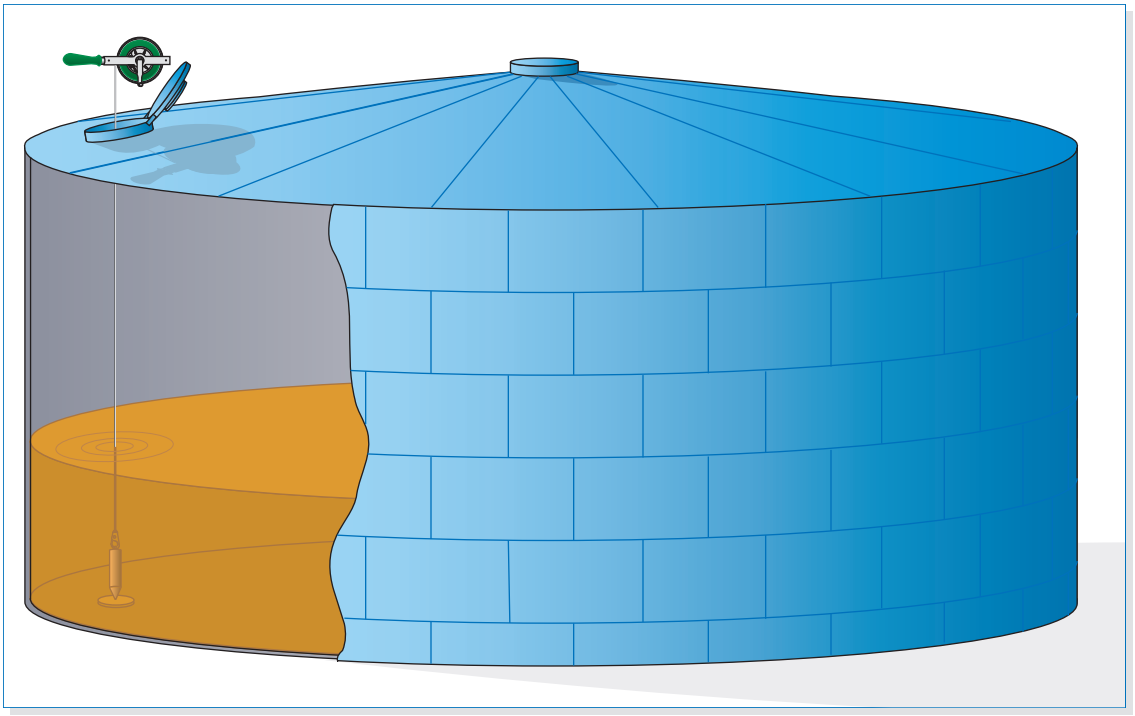
Training Module

Manually Gauge Non-Pressurized Above-Ground Tanks



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- Training Module and Self-Check
- Knowledge Check and Answer Key
- Blank Answer Sheet
- Performance Check

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Contents

Contents (continued)

Training Objectives

Upon completion of this training kit, you will be able to:

- Describe the purpose and importance of manually gauging non-pressurized above-ground tanks
- Describe tank tables
- Describe innage and outage tank gauging methods
- Describe innage and outage gauges
- Describe safety hazards and precautions when tank gauging
- Describe the bob cut innage tank gauging procedure
- Describe the bob cut outage tank gauging procedure
- Manually gauge a non-pressurized above-ground tank using the bob cut innage tank gauging procedure
- Manually gauge a non-pressurized above-ground tank using the bob cut outage tank gauging procedure
- Calculate gross volume of stored liquid after manually gauging the tank
- Describe portable tank gauges
- Describe temperature measurements

Refer to the glossary, located at the end of this module, for an explanation of terms.

1 Introduction

In the oil and gas industry, non-pressurized above-ground tanks are used to store liquids (well emulsions, produced water, fuel, field chemicals, by-products from gas processing, and refined petroleum products) at well sites, batteries, plants, and terminals.

The height of a tank's contents is measured to determine the volume of the contents. Height can be measured automatically, using automatic tank gauges (ATGs), or manually. This training kit focuses on manual tank gauging.

Tanks are manually gauged for the following purposes:

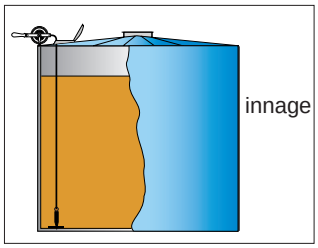
- for custody transfer: to determine the volume of product transferred for sales and receipts. Product is gauged before the transfer (opening gauge) and after the transfer (closing gauge).
- for determining inventory
- to calibrate an ATG after initial installation
- to verify ATG readings
- to confirm meter readings
- for leak detection

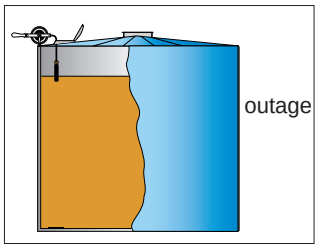
Tanks are gauged in accordance with the standard practice published by the American Petroleum Institute (API): *Manual of Petroleum Measurement Standards*, Chapter 3—*Tank Gauging*; Section 1A—*Standard Practice for the Manual Gauging of Petroleum and Petroleum Products.*

Free water
The water that has settled out of the oil, forming a layer at the bottom of the tank.

Overview

An operator uses a steel gauging tape and bob to manually gauge a tank. The operator lowers the bob from the gauging hatch (sometimes called the thief hatch) at the top of the tank until the bob touches a datum (strike) plate at the bottom of the tank (for the innage method) or just touches the liquid (for the outage method). The operator may also use a water gauge bar to determine the free water level.





After gauging the tank, the operator:

- reads the height of the liquid from the gauge tape (innage method) or calculates the height of the liquid (outage method)
- uses the height to read the gross observed volume from a tank capacity table (also called a strapping table)
- may calculate gross standard volume (GSV) by correcting the gross observed volume for product temperature
- may calculate net standard volume (NSV) by subtracting the volume of sediment and water from the GSV

Contents of this Training Kit

This training kit focuses on safe and reliable manual tank gauging. The kit is aimed primarily at pipeline terminal/ field operators who are responsible for manually gauging tanks. The kit includes:

- a description of innage and outage gauging equipment and procedures
- safety hazards and precautions related to manual tank gauging
- practices which ensure the accuracy of manual tank gauging
- innage and outage gauging procedures and product volume calculations
- a brief description about temperature measurement
- a brief description of portable tank gauges

This training kit does **not** include:

- procedures for measuring temperature
- information about taking samples, measuring density, or measuring sediment and water content

This kit is one of a series of two HDC training kits related to storage tanks. The other kit is *Manually Sample Non-Pressurized Tanks*.

2 Types of Gauging

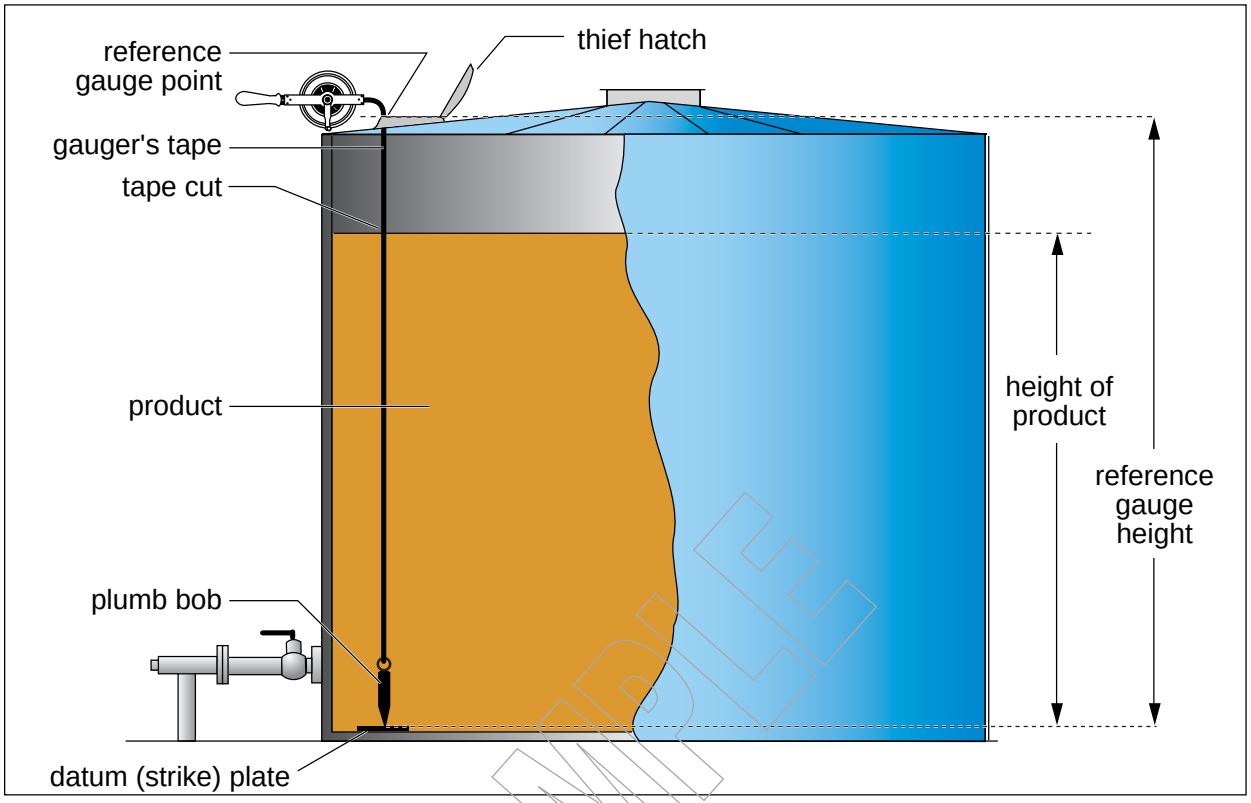
Tanks are manually gauged using two different methods: innage and outage. If required, the oil/water interface is also gauged, using the innage method.

2.1 Innage Gauging

Innage gauging (also referred to as *bottom gauging* or *dip gauging*) measures the distance from the datum (strike) plate (or the bottom of the tank if there is no datum plate) to the surface of the product (see Figure 1). An innage bob is used for innage gauging (see Figure 4). Innage gauging is commonly used when:

- tank contents are not viscous
- the operator is able to lower the bob to the bottom of the tank

Figure 1—Innage Gauging



Reference gauge point
The point on the gauging hatch from which measurements are made.

Reference gauge height
The distance between the reference gauge point at the gauging hatch and the datum plate or bottom of the tank.

Advantages of innage gauging include the following:

- the height of the liquid in the tank is *directly* measured; the effects of tank **reference gauge point** movements are therefore eliminated. Innage gauging is recommended whenever reference gauge point changes are suspected.
- the operator can compare the tape reading at the reference gauge point with the **reference gauge height** each time a tank is gauged and thus can note any variances. (As a tank fills, the tank walls can expand; this expansion may result in movement of the reference gauge point and/or the datum plate.)

Disadvantages of innage gauging include the following:

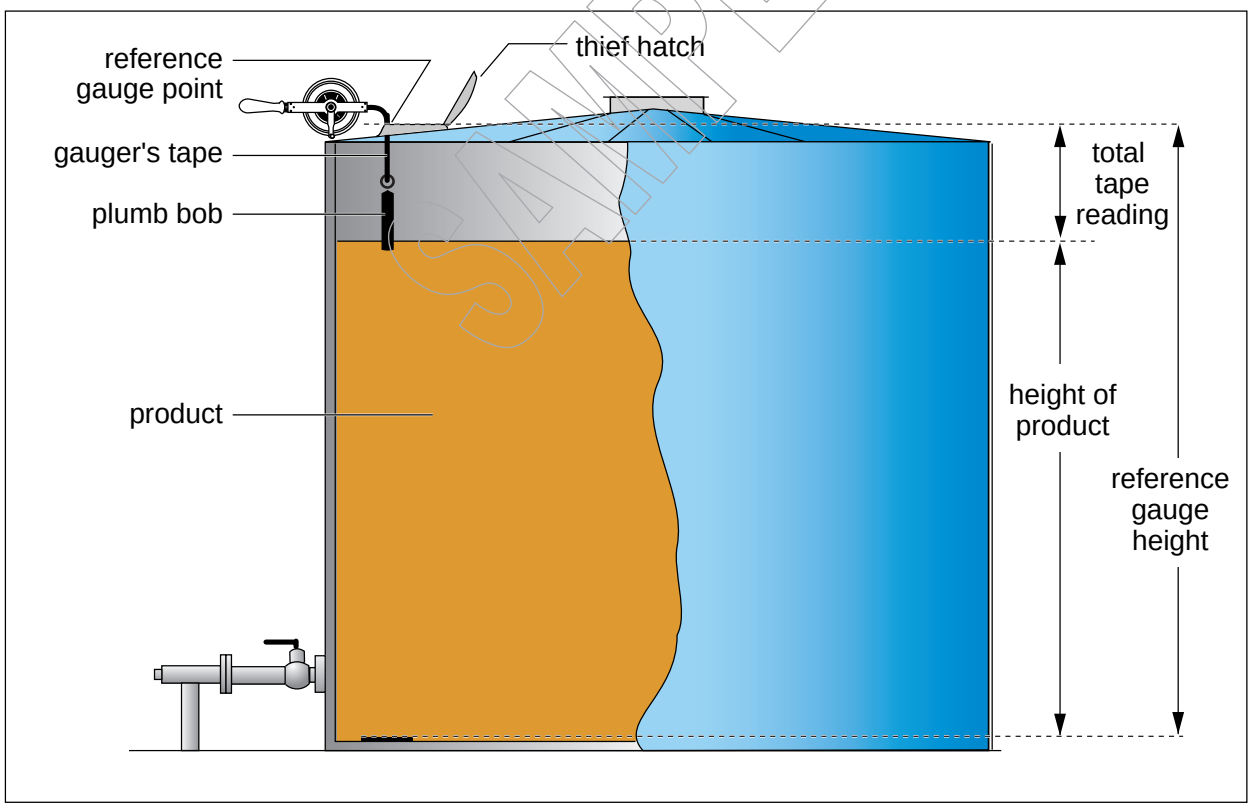
- measurement inaccuracies resulting in faulty readings. For example:
  - the tape may be lowered too far, causing the bob to tilt

  - sedimentation on the tank bottom may prevent the gauge from actually reaching the bottom or may cause the bob to tilt
  - in highly viscous products, the bob and tape may tilt
- the gauging tape is immersed in the liquid and must be thoroughly cleaned while the tape is being reeled in. In addition to being a messy and time-consuming procedure, with corrosive or toxic products, cleaning the gauge tape exposes the operator to health or safety hazards.

2.2 Outage Gauging

Outage gauging (also referred to as *ullage* gauging or *top gauging*) measures the distance from the surface of the product in the tank to a reference gauge point on the gauge hatch at the top of the tank (see Figure 2).

Figure 2—Outage Gauging



An outage bob is used for outage gauging (see Figure 4). Outage gauging is commonly used when the tank contents are:

- corrosive or toxic
- extremely viscous
- clear (such as water or gasoline)

The height of liquid must be calculated: height equals the reference gauge height of the tank less the gauge reading at the reference gauge point.

One advantage of outage gauging is that only the bob is immersed in the liquid and cleanup is quick.

Disadvantages of outage gauging include the following:

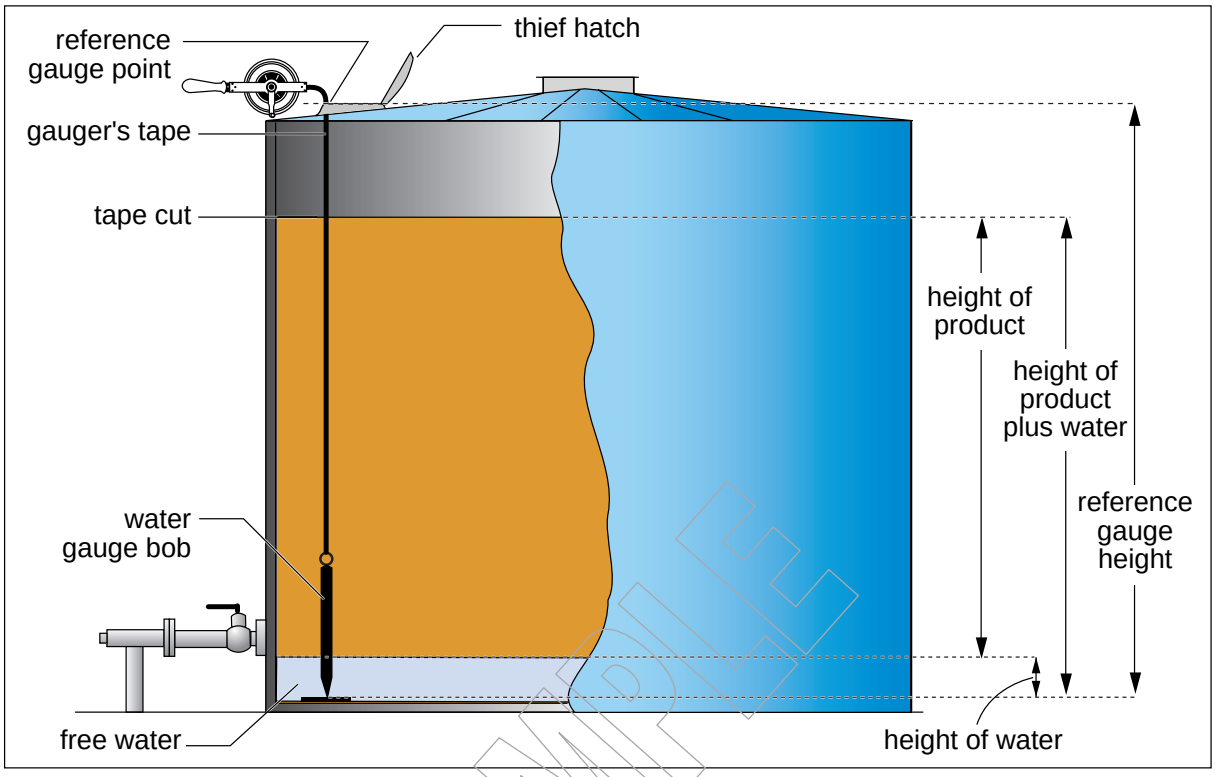
- the height of the liquid in the tank is *indirectly* measured: the actual height must be calculated
- the operator cannot observe any reference gauge point variances. (Reference gauge point variances can only be seen with innage gauging when the tape is lowered to the datum plate.) Outage gauging should only be used if the reference gauge height does not vary with product level in the tank.

2.3 Free Water Gauging

In tanks where free water has separated from the oil, a gauge tape with a water gauge bob is used to measure the free water level, using the innage method (see Figure 3), as follows:

- The bob is coated with a water indicating paste and lowered until it touches the datum plate. Only the free water reacts with the water paste, causing a color change.
- The tape is withdrawn after:
  - ten seconds, for light products
  - five minutes, for heavy, viscous products
  - or as specified by the manufacturer of the gauge paste
- The height of the water is read directly from the water gauge bob.
- The height of product is the reading on the tape less the height of the water.

Figure 3—Free Water Interface Gauging



Free water gauging is relatively accurate when the density differential between the oil and water is large and when the liquid in the tank is not emulsified. If the liquid is emulsified (i.e., if the water has **not** separated from the oil), the tank contents must be sampled and the sediment and water must be measured to determine more precise oil and water volumes.

2.4 Gauging Equipment

Gauge Tapes

Gauges consist of a bob attached to a steel gauging tape. Gauging tapes are made of steel or corrosion-resistant material wound onto a reel with a crank and a handle. The free end of the tape is equipped with a snap hook for attachment of the bob. Newer gauging tapes are equipped with a grounding cable.

Gauges can be graduated in:

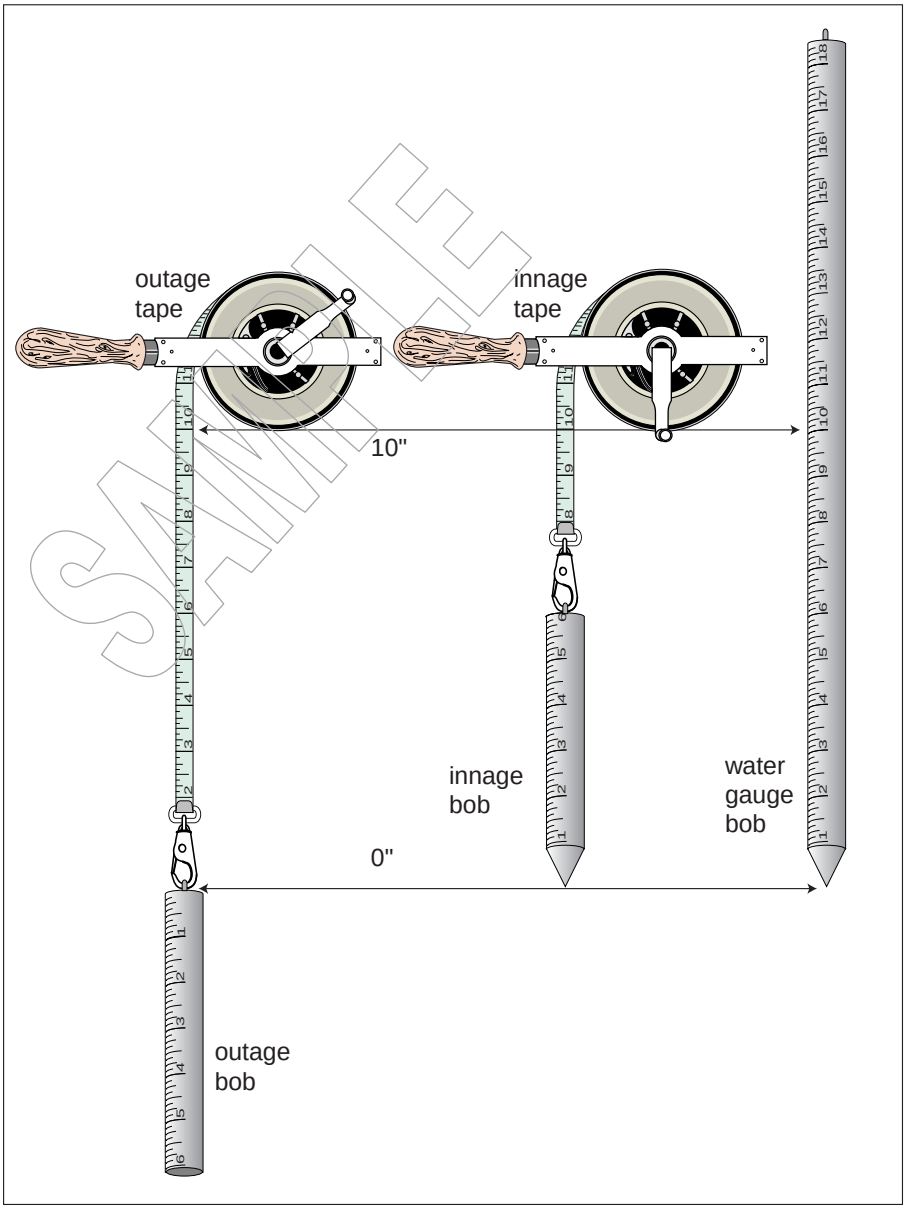
- feet, inches, and fractions of an inch (imperial)
- feet and hundredths of a foot (imperial)
- metres, centimetres, and millimetres (metric)

Some gauges have a metric scale on one side and an imperial scale on the other side.

The graduations on gauging tapes are specific for either outage gauging or innage gauging. Note on Figure 4 that:

- the outage tape ends at zero (at the point of contact between the snap hook and the bob eye)
- the innage tape does **not** end at zero: the tip of the innage **bob** is the zero point

Figure 4— Outage, Innage, and Water Gauge Bobs



Gauge bobs are cylindrical, square, or rectangular rods, 15, 30, or 45 cm (6, 12, or 18 in.) long. Bobs are made of spark- and corrosion-resistant material, and graduated in millimetre, $^1/_8$ inch, or $^1/_{100}$ foot increments, as follows:

- Innage bobs
  - have a tip at the bottom
  - have the zero point at the **bottom** of the bob
- Outage bobs
  - usually have a flat bottom
  - have the zero point at the **top** of the bob and a higher number at the bottom of the bob
- Water gauge bobs
  - are innage bobs: the zero point is at the **bottom** of the bob
  - are cylinders, 30-centimetre or 45-centimetre (12-inch or 18-inch) long
  - should be cylindrical rather than square or rectangular to prevent water paste inaccuracies

- Innage bobs must be used with innage tapes. The graduation on the tape and bob must be continuous.
- Outage bobs must be used with outage tapes.

Gauge Paste

Different types of indicating paste are available. Gasoline indicating paste is used with very light petroleum products which evaporate quickly. Water indicating paste is used to indicate the free water level. The paste is evenly spread on the bob (for outage and free water gauging) before the bob is lowered into the product. The paste changes color or dissolves when it contacts the target product. Various gauge pastes may need to be tested to determine the best paste for a particular product.

Chalk or talcum powder are **not** acceptable substitutes for gasoline indicating paste, because the product tends to creep up the chalk and cause inaccurate readings.

3 Safety

Gauging petroleum product tanks is a hazardous operation, which exposes the operator to both physical and chemical hazards. This section describes:

- physical hazards and precautions
- chemical hazards and precautions
- safety before climbing to the roof
- safety while gauging
- gauging tanks with floating roofs

3.1 Physical Hazards

Physical hazards include:

- slips, trips, and falls; for example:
  - slipping on spilled product, icy ladders, gratings, catwalks
  - tripping over or getting tangled in lines, tapes, and lanyards
  - falling while ascending and descending tank ladders
  - losing balance during high winds
- potential for fire and explosion. Combustible gas mixtures around the tank and at the gauge hatch can be ignited by:
  - static electricity
  - electric storms

To protect against physical hazards, operators must take the following precautions:

- Do not gauge a tank during an electric storm or during a very windy day.
- Petroleum products tend to accumulate static electricity. Make sure all clothing and all equipment (such as tapes, gauges, and lines) will not hold a static charge.
- If a flashlight is required, make sure it is explosion-proof.
- Follow your company's Fall Protection Code of Practice. Depending on your company's code and the facilities at each site, safety requirements may include:
  - wearing fall arrest equipment (e.g., full body harness and retractable lanyard)
  - using vertical and horizontal life lines or climb assist equipment

  - raising collapsible guard rails around the gauge hatch area
  - assigning a trained spotter at the base of the tank for emergency assistance
- When climbing ladders and stairs, always keep three-point contact (two hands, one foot or two feet, one hand):
  - Don't carry gauging equipment and supplies in your hands while climbing: carry all materials in a pack on your back, shoulder, or belt.
  - If you will be gauging and also sampling product in the tank, leave all necessary materials on the ground. Tie a rope to the materials and to your waist. Make sure the rope hangs from your back so that your feet don't get tangled in the rope while you climb the ladder. When you are on the roof and safely anchored, use the rope to pull up the materials. Use the rope to lower the materials to the ground after use.
- When climbing ladders and stairs, continuously electrically ground yourself by maintaining contact with the ladder or handrail.
- Wear approved safety boots with non-skid soles. Clean mud, snow, and other slippery substances off your boots before climbing.
- Be prepared to respond to any emergency according to your company's Emergency Response Plan.

3.2 Chemical Hazards

Chemical hazards include:

- inhalation of toxic vapors, such as hydrogen sulfide (H_2S) and gasoline
- absorption of toxic materials through the skin

To protect against chemical hazards, operators must take the following precautions:

- Before gauging a tank, review the material safety data sheet (MSDS) for the product in the tank. The MSDS outlines the:
  - product's hazards, including potential health effects
  - toxicological information, including routes of entry and toxic effects

  - personal protection required during exposure to the product, including the protection required for eyes, hands, feet, and respiratory tracts
  - first aid measures for eye contact, skin contact, inhalation, and ingestion
  - fire-fighting information, including flammability, flash point, and products of combustion
  - actions to take if the product is accidentally released
  - handling and storage
- If gauge paste will be used, review the MSDS for the specific paste product. Some types of gauge paste are nontoxic; other types can be toxic if accidentally swallowed, absorbed through the skin, or rubbed into the eye.
- Wear the personal protective clothing and equipment recommended in the MSDS for the applicable product in the tank. Depending on the particular product, personal protective equipment includes:
  - chemical-resistant gloves. The MSDS specifies the type of glove that will prevent the product from soaking through and contacting your skin. For some products, a single glove may not be effective; layering two different types of gloves may be necessary for effective protection. Failure to select the correct glove(s) can allow product to enter the bloodstream via the skin.
  - eye and face protection. Some products require safety goggles and a face shield.
  - respiratory protection. For some products, a cartridge respirator equipped with one or more specified filters is adequate; for other products, a supplied air respirator is required.
  - flame-resistant coveralls
  - chemical-resistant clothing under the coveralls
- Protect against physical contact with petroleum products:
  - If you spill product on your hands, wash your hands as soon as possible, using the washing technique outlined in the MSDS.
  - If you spill product on your coveralls, change coveralls as soon as possible, especially if you are not wearing chemical-resistant underclothing. If the product is highly corrosive or extremely toxic, remove product-soaked clothing immediately.

Products Containing H_2S

H_2S (hydrogen sulfide) is an extremely toxic gas that can cause unconsciousness and death if safety precautions are not taken or are inadequate. For tanks that may contain sour product (i.e., products that contain H_2S), the following additional safety precautions are necessary:

- Before entering the tank area, conduct a pre-job assessment and develop a plan for carrying out the work safely, following your company's policy or procedure. Ask yourself such questions as:
  - From what direction will I approach the tank?
  - What protection do I need before entering the area?
  - How will I apply my company's H_2S Code of Practice?
  - Who will be my safety watch?
- Check the area around the tank for H_2S concentrations, using H_2S detection equipment.
- If H_2S gas levels are detected, follow the procedures listed in your company's H_2S Code of Practice which usually entail:
  - getting a Safe Work Permit before gauging
  - ensuring a trained and properly equipped safety watch person is present during gauging
  - using self-contained breathing apparatus (SCBA) during gauging

3.3 Safety before Climbing to the Roof

Before climbing to the tank roof conduct a pre-job assessment and develop a plan for carrying out the work safely:

End of Sample

A full licensed copy of this kit includes:
• Training Module and Self-Check
• Knowledge Check and Answer Key
• Blank Answer Sheet
• Performance Check