TANK GAUGING FOR PETROLEUM

AND

PETROLEUM PRODUCTS

SECOND EDITION

AUGUST 2014

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

Standards and Research department

No.17, Street14, North kheradmand

Karimkhan Avenue, Tehran, Iran.

Postal Code- 1585886851

Tel: 021-88810459-60 & 021-66153055

Fax: 021-88810462

Email: Standards@nioc.ir

GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

CONTENTS: PAGE No.

1. SCOPE

This Standard covers the general technical requirements needed for preparation of purchase specification, selection of the types and equipment operation used in gauging oil and liquid petroleum products in various type of tanks and containers.

Note 1:

This is a revised version of this standard, which is issued as revision (1)-2006. Revision (0)-1997 of the said standard specification is withdrawn.

Note 2:

This is a revised version of this standard, which is issued as revision (2)-2014. Revision (1)-2006 of the said standard specification is withdrawn.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

API (AMERICAN PETROLEUM INSTITUTE)

MPMS 3.1A	"Manual of Petroleum Measurement Standards Chapter 3.1A Standard Practice for the Manual Gauging of Petroleum and Petroleum Products"
MPMS 3.1B	"Manual of Petroleum Measurement Standards Chapter 3-Tank Gauging Section 1B-Standard Practice for Level Measurement of Liquid Hydrocarbons in Stationary Tanks by Automatic Tank Gauging"
MPMS 7	"Manual of Petroleum Measurement Standards Chapter 7-Temperature Determination"
MPMS 12.1.1	"Manual of Petroleum Measurement Standards EI Hydrocarbon Management HM 1- Part 1: Calculation of Static Petroleum Quantities-Upright Cylindrical Tanks and Marine Vessels"
API 2555	"Method for Liquid Calibration of Tanks"

IP (THE INSTITUTE OF PETROLEUM)

BS ISO-4266-1	"Petroleum and Liquid petroleum products-measurement of level and temperature in storage tanks by automatic methods- part1: measurement of level in atmospheric tanks"
BS ISO-4266-2	"Petroleum and Liquid petroleum products-measurement of level and temperature in storage tanks by automatic methods-part2: measurement of level in marine vessels"
BS ISO-4266-3	"Petroleum and Liquid petroleum products-measurement of level and temperature in storage tanks by automatic methods-part3: measurement of level in pressurized storage tanks (non-refrigerated)"

BS ISO-4266-4	"Petroleum and Liquid petroleum products-measurement of level and temperature in storage tanks by automatic methods-part4: measurement of temperature in atmospheric tanks"
BS ISO-4266-5	"Petroleum and Liquid petroleum products-measurement of level and temperature in storage tanks by automatic methods-part5: measurement of temperature in marine vessels"
BS ISO-4266-6	"Petroleum and Liquid petroleum products-measurement of level and temperature in storage tanks by automatic methods-part6: measurement of temperature in pressurized storage tanks (non-refrigerated)"

NEMA (NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION)

NEMA 250	"Enclosures for Electrical Equipment (1000 Volts Maximum)"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-IN-100	"Engineering Standard for General Instrumentation"
IPS-E-IN-110	"Engineering Standard for Pressure Instruments"
IPS-E-IN-120	"Engineering Standard for Temperature Instruments"
IPS-E-IN-130	"Engineering Standard for Flow Instruments"
IPS-E-IN-140	"Engineering Standard for Level Instruments"

3. UNITS

This standard is based on international system of units (SI), as per IPS-E-GN-100 except where otherwise specified.

4. TERMINOLOGY

This chapter provides a glossary of terms, definitions and general information for use in tank gauging.

4.1 Reference Point

The fixed point or mark at or near the top of a tank, (Fig. 1), from which measurement are made. This point may be a bench mark, a small fixed plate inside the gauging hatch or narrow groove cut horizontally on the inside of the hatch.

4.2 Reference Depth (Gauging Height)

The distance from the reference point to the bottom of the tank (Fig. 1). Preferably, this distance should be stamped on the fixed bench-mark plate.

4.3 Datum Plate

A level metal plate, preferably attached to the tank shell, located directly under the reference point to provide a fixed contact surface for the innage bob. The datum plate is optional equipment. (Fig. 1)

4.4 Cut

The line of demarkation on the measuring scale made by the material being measured. (Fig. 1)

4.5 Innage Gauge

The depth of liquid in a tank, measured from surface of the liquid to the tank bottom or to a fixed datum plate. (Fig. 1)

4.6 Outage Gauge (Ullage)

The distance from the reference point to the surface of the liquid in a tank. (Fig. 1)

4.7 Opening Gauge

The measurement in a tank before a delivery or receipt.

4.8 Closing Gauge

The measurement in a tank after a delivery or receipt.

4.9 Shell Full

Designates that a tank is filled to its shell capacity.

4.10 Shell Outage

The distance from the reference point to the surface of the liquid. (Fig. 2)

4.11 Dome Innage

The depth of liquid in the dome of a tank, measured from the reference point. (Fig. 2)

4.12 Dip-Point

The point on the bottom of a container which the dip weight touches during gauging and from which the measurement of the oil and water depths are taken. The dip-point usually corresponds with the datum-point.

4.13 Dip-Tape

A graduated tape used for measuring the depth of liquid in a container, either directly by dipping or indirectly by ullaging.

4.14 Displacer

A displacer usually takes the form of a disc or plate and is a surface detection element which is suspended from a level gauge and moves in a vertical direction to follow the change in liquid level. The displacer disc or plate has a higher mass than the liquid it displaces.

4.15 Dip-Hatch

The opening in the top of a container through which dipping and sampling operations are carried out.

4.16 Dip-Rod or Dip-Stick

A rigid length of wood or metal usually graduated in units of volume, for measuring quantities of liquid in a container.

4.17 Dip-Weight

A weight attached to a steel dip-tape, of sufficient weight to keep the tape taut and of such shape as to facilitate the penetration of any sludge that might be present on the dip-point or the dip plate.

4.18 Dipping Reference Point

A point clearly marked on the dip-hatch directly above the dip-point to indicate the position at which dipping shall be carried out.

4.19 Gauging

The process of taking all the necessary measurements in a container in order to determine the quantity of liquid which it contains.

4.20 Float

A detecting element floating on or in the liquid in a tank which moves in a vertical direction to follow the change in liquid level.

4.21 Float Guide Wires

Solid wires or flexible cables used to guide the travel of an automatic gauge float.

4.22 Floating-Roof Tank

A tank in which the roof floats freely on the surface of the liquid contents, except at low levels when the weight of the roof is taken on its supports on the tank bottom.

4.23 Float Well

A vertical cylindrical structure built into the roof of a floating-roof tank to contain and guide the detecting element.

4.24 Gauge Head

The housing of the liquid-level measuring element which may include the indicator, transmitter and associated equipment.

4.25 Still Pipe

A vertical cylindrical pipe built into a tank to contain the liquid level-detecting and arranged to reduce errors arising from turbulence or agitation of the liquid.

4.26 Anchor Weight

A specified weight to which the float guide wires or cables are attached to hold them taut and plumb.

4.27 Automatic Gauging Tape

The flexible measuring or connecting element (a section of which is graduated) which is used to measure the liquid level in tanks by the automatic gauge method.

4.28 Counter Weight

A device which exerts force or tension on the tape or cable to hold connecting elements tight.

4.29 Floatation Level

The depth of submergence of a buoyant automatic gauge float in a liquid of known density or weight.

4.30 Negator Motor

The Negator is a strip of flat stainless steel spring which has been given a curvature by continuous heavy forming at a constant radius, so that in its relaxed or unstressed condition, it remains in the form of a tightly wound spiral. This form permits a compact mounting within the gauge head. The stainless steel Negator motor eliminates counter weight assembly.

4.31 Pressure Lock

A manually operated semi-automatic gauging device, self enclosed, which is used for the prevention of vapor losses in the gauging of atmospheric pressure, variable vapor space, and high pressure tanks.

4.32 Seal Units

An assembly used in tank installations to seal off the gauge assembly from the tank vapors.

4.33 Selsyn

A type of electric a.c. motor used to transmit motion and position.

4.34 Sheaves

Support wheels over which the tape, wire or cable rides.

4.35 Tape Tester or Manual-Operation Checker

A mechanical device, knob, or lever (which can be engaged through its connecting tape or cable) for lifting or rocking the float in order to assure that the float is free.

4.36 Tape

A generic term used to describe the means serving as the connecting element between the liquid level-detecting element and the gauge head mechanism.

4.37 Ullage-Paste

A paste which is applied to an ullage-rule or dip-tape and weight to indicate precisely the level at which the meniscus cuts the graduated portion.

4.38 Ullage-Rule

A graduated rule attached to a dip-tape to facilitate the measurement of ullage.

5. MANUAL TANK GAUGING DEVICES

5.1 Gauging Tapes

Gauging tapes, graduated tapes with reversed numerals on the inside for easy reading, should be used for the innage and outage gauge measurement. (Fig. 3)

Material	Steel (corrosion-resistant material).
Length	One continuous tape of sufficient length for the height of the tank.
Width Thickness	The cross-sectional area of the tape shall be such that the tape in a horizontal position on a flat surface will not stretch by more than a unit strain of 0.0075 %.

Housing	A durable reel and crank
Free end	Fitted with a spring snap-catch or other locking device to which the bob can be attached.

Scale:

Innage tape	Graduated on one side in meter and centimeter to at least 3 mm divisions, accurate to 3 mm per 30 m at 15°C, and such that the tip of the bob, when attached, will be the zero point of the scale.
Outage tape	Graduated on one side in meters and centimeters to at least 3 mm divisions, accurate to 3 mm per 30 m at 15°C, and such that the zero point of the scale is the point of contact between the snap catch and the eye of the bob.

5.2 Gauging Bobs

a) Plain Bobs and Water Gauge Bars

Graduated cylindrical, square, or rectangular bobs, or water gauge bars, with following specifications: (Fig. 3)

Material	Corrosion resistant metal
Length:	
Bobs	150-300 mm
Bars	450 mm minimum
Diameter or width	25 mm maximum
Weight	Sufficient to hold the gauging tape taut.
Scale:	
Innage Bobs and Bars	Graduated on one side in inches with at least 1/8 in. subdivisions; in tenths of a foot with at least hundredths of a foot subdivisions; or in centimeters with at least 1 mm subdivisions. The zero point of the scale is at the tip of the bob.
Outage/Ullage Bobs	Graduated on one side in inches with at least 1/8 in. subdivisions; in tenths of a foot with at least hundredths of a foot subdivisions; or in centimeters with 1 mm subdivisions. The zero point of the scale is at the inside of the eye, except for the extension outage/ullage bob (see Fig. 3).
Eye	An integral part of the bob or bar, preferably reinforced with a hardened bushing to prevent wear.
Tip	Innage bobs and bars shall have a conical tip of sufficient hardness to prevent damage by contact with other metal.

b) Deep-Grooved Outage Bobs

To reduce errors caused by evaporation, the deep-grooved bob may be used with the outage tape, for gauging petroleum liquids. The bob is the same as the plain outage bob, except that grooves extend across one of the faces adjacent to the graduated face. These grooves are 0.4 mm deep by 0.8 mm wide and are cut at 3 mm intervals to correspond with the scale graduations, the scale and the combination of each graduation and groove to be accurate within 0.8 mm (Fig. 3).

c) Extension Outage Bob

The extension bob is designed for use with innage tape. The specifications for the graduated portion of the bob are the same as for plain bob.

5.3 Gauging Sticks and Poles

a) Tank Gauge Stick

A gauge stick, Fig. 4, made of varnished hardwood or other corrosion-resistant material with suitable length (approximately 900 mm) and 19 to 25 mm wide by 9 to 19 mm thick should be used for gauging of non-pressure tank cars.

The stick has two scales with a common zero 300 mm from the lower end, graduated upward and downward in 3 mm divisions, and accurate to at least 0.8 mm. A brass angle should be attached to the stick so that the lower side of its horizontal arm is 9 mm above the zero on the longer scale. When the stick is placed in a vertical position with the angle resting on the upper side of a tank car shell of nominal 9 mm thickness, the scale zero coincides with the underside of the shell.

b) Gauge Pole

A gauge pole (Fig. 4), which is made of varnished hardwood or other corrosion-resistant metals should be used for innage gauging of small stationary tanks, tank cars.

The pole should be long enough to gauge the tank and should be approximately 25 mm wide by 19 mm thick. To prevent damage, a metal tip or cap is recommended for poles made of wood. One side of pole should have a scale graduated in meter and centimeter to at least 3 mm divisions, accurate to at least 1.5 mm, and with its zero at the bottom or tip.

5.4 Thermometers

5.4.1 Liquid temperature in tanks should be determined by total immersion thermometers with etched graduated glass stems and with bulbs made of Corning normal or equivalent thermometric glass, mercury filled, with nitrogen gas above the mercury column. (Fig. 5)

5.4.2 Portable electronic thermometers

The electronic type thermometers may be used to measure the temperature in single or multi point. MPMS 7 shall be followed for the measuring procedure.

5.5 Sampling Apparatus

Samples for determining the API gravity and percent of suspended sediment and water may be taken by a graduated oil thief or with a beaker or bottle with the following specifications:

Material	Corrosion-resistant metal of sufficient thickness or reinforced to prevent breakage
Length	300 mm minimum
Diameter or width	45 mm minimum inside, 90 mm maximum outside
Scale	Graduated on one side of the thief to at least 3 mm divisions, accurate within 0.8 mm, and reading upward from the bottom of the thief.

Top	open
Bottom	Equipped with closure which will allow free passage of liquid when in the open position, and which is operated by a separate cord or trip lever having a graduated adjustable arm and actuated by contact with the bottom of the tank.

In this regard MPMS 3.1A shall be followed.

6. AUTOMATIC TANK GAUGING SYSTEM

Automatic Tank Gauging system (ATG), considers a highly precise measurement of liquid level and temperature as the basis for accurately computing volumetric and mass quantities of products stored in containers.

Automatic level measurement is more accurate and reliable than manual gauging. The level sensing device is constantly on the liquid surface whereas introduction of a manual tape always causes a ripple on the surface. The measuring wire or tape is always under constant tension whereas the measuring tape deviates from the calibration tension when the plumb bob touches the dip plates or the bottom. The surface tension of the liquid has virtually no influence on the immersion of the displacer or float whereas the meniscus produces a reading error on manual tape depending on the liquid, the cleanness of the tape and use of paste.

If mutually agreed, properly designed, installed and maintained automatic tank gauging devices of known accuracy may be used to determine levels in storage tanks for the purpose of custody transfer.

6.1 Types of Automatic Tank Gauges

Automatic tank gauges are instruments which measure liquid levels automatically in contrast to those operated manually with a hand gauge line.

6.1.1 Direct-reading automatic tank gauges

Such gauges shall read directly at tank-top or ground eye level on a graduated tape or have analog or digital indication in meter, centimeter, and millimeter subdivisions.

The use of any type of automatic tank gauges requires either that its accuracy be unaffected by variations in gravity or, if affected, the manufacturer shall so state in the certification, outlining the extent of such error with liquid gravity change. Where this error is significant such gravity-responsive float-type gauge must not be used for custody transfer on any tank where the gravity changes, unless the gauge is always reset for each different products gravity change.

6.1.2 Remote-reading automatic tank gauges

The main measuring device is the automatic tank gauge, which may also be made to read at one or more remote points from the point of measurement at the tank by superimposing a secondary system known as remote transmission or telemetering.

Remote transmitting systems used with automatic tank gauges shall be electronic in principle, normally employing a single or selective type of receiver for single or multiple tank installation. The electronic based system shall be capable to tie into wiring network of a data commutation highway.

Regardless of which type of remote system is used, remote gauge readings should be satisfactory for custody transfer purposes only if they meet the following conditions:

a) It must be shown that the remote reading is unaffected by gauge shake-out (lifting or rocking the float system to assure unrestrained equilibrium); that the gauge is sufficiently sensitive as not to require shake-out prior to reading, or if the gauge is not sufficiently sensitive, that remote gauge operation is such as to simulate shake-out.

b) If the transmission error is not zero and the remote readings are used for custody transfer, the gauge must be calibrated and read on the basis of the remote reading only.

c) The transmission system shall incorporate sufficient security techniques to guarantee against communication system interferences which could cause false or erroneous indication or registry of information. Detection circuits shall reject false data as well as permit manual or automatic requesting of new data.

d) Before the remote readout is used for custody transfer, it should be checked to confirm that the reading does not change when the repeatability checker (or similar device) is actuated.

e) The reading of an ATG to be used for custody transfer application should agree with a certified measurement instrument within ±1 mm over the entire range of the ATG. The certified measurement instrument should be traceable to the national standards and should be provided with a calibration correction table. The uncertainty of the reference should not exceed 0.5 mm, with the calibration correction applied. In this regard MPMS 3.1B shall be followed.

6.1.2.1 Tank gauging receiving unit

Several types of remote receiving units ranging from individual level indication, to computerized display and processing systems may be used to collect the data from filed instruments, compute and organize the measuring data and present the inventory data in a logical format for the user to work with. This format shall be configurable by the user during system setup. The unit is located in the control room at the tank farm or at some other remote locations and, should be able to have following features:

6.1.2.1.1 Scan all tanks monitored by the ATG system in a manner that meets the requirements for data acquisition.

6.1.2.1.2 Display all variables such as level (including water interface level), volume, mass, temperature, pressure, gravity, density and gauge address as appropriate on real time basis presenting a total overview of the tank farm, views of groups of tanks, product summaries, detailed views of single tank as well as trends and histograms.

6.1.2.1.3 Accept manual inputs such as gravity or S & W as needed.

6.1.2.1.4 Store tank calibration tables, volume correction table(s), and all constants required in the measurement if these table(s), and constants are not stored in the interface unit mounted in the field.

6.1.2.1.5 Perform or display computations and calculate quantities such as gross and net barrel volumes, mass, transfer rates, and quantities for tank inventories.

6.1.2.1.6 Perform data validity checks and alert the operator errors as detected.

6.1.2.1.7 Reset on the basis of manual gauging, should there be a transmission error.

6.1.2.1.8 Display alarms such as maximum safe level and low pump-out level.

6.1.2.1.9 To be configurable via the keys on the front panel and a displayed menu.

6.1.2.1.10 The transmission between the indicator and field instruments shall be digital based on standard protocols. Manufacturer's protocols with company approval are acceptable.

6.1.2.1.11 The unit should have interfacing capability to most computers, PCS and data loggers.

6.2 The More Commonly Used Technologies in ATG

Currently most new automatic tank gauging engages the following technologies:

- Liquid level measurement
- Spot or average temperature measurement.
- Volume computation -gross and standardized.
- Mass calculations.
- Density measurements

There are many technologies which measure liquid level, among them, the most common tank gauging devices are:

- Float-operated Automatic Tank Gauges (FTG)
- Servo-operated Automatic Tank Gauges (STG)
- Radar Tank Gages (RTG)
- Resistive or Electro-ohmic Tank Gauges

The most common mass tank gauge is:

- Hydrostatic Tank Gauging (HTG)

The direct volumetric technologies are level based, while the direct mass technologies are pressure based.

The level measurement devices are generally tank-top or side mounted, whereas the pressure (hydrostatic head) systems are almost always installed into the shell of the tank.

Technologies which measure innage (measuring liquid level from the tank bottom or bottom datum reference) would be the resistive, hydrostatic, and inductive tank gauging. In Outage or Ullage tank gauging (measuring liquid level from a tank-top reference point down to the liquid surface), float actuated automatic tank gauging, servo-operated ATG and radar ATG are commonly used.

6.2.1 The automatic float gauges

6.2.1.1 Basically the float-operated tank gauge derives its potential power from the negator-spring motor in the gauge head and weight of the float. The float should be guided by guide wires or stranded cable and suspended from a perforated stainless steel tape which is stored in the gauge head.

6.2.1.2 Due to the intrinsic mechanical friction and hysteresis, the accuracy is ±6 mm on tank side installation and 3 to 5 mm on tank-top installations. Accuracy may be further impaired when encoders and switches are mounted on the instrument due to the increased torque requirements to position these devices.

6.2.1.3 To minimize the effects of a turbulent liquid surface, a stilling well should be installed.

6.2.1.4 An encoder may be mounted on the gauge head to transmit level data, upon request, to the remote computer.

Product temperature may be inputted to the encoder directly from a spot, single-point sensor or an averaging temperature detector.

6.2.2 The servo gauges

6.2.2.1 Servo power gauges eliminate the effect of mechanical friction in the system. The servo balance requires a very low actuating force and consequently a small displacer can be used as a level sensing device.

6.2.2.2 The electromechanical components of the gauge shall be housed in a water proof enclosure (at least IP 65) and suitable for classified area.

6.2.2.3 Minimum servo gauges accuracy shall be in the range of 1 mm to 2 mm.

6.2.2.4 Servo gauges shall be installed on the tank roof on a stilling well.

6.2.3 The radar tank gauges

6.2.3.1 The radar gauge is a non-contact technology. The radar transmitter/receiver is mounted on tank-top. The transmitter emits microwaves towards the surface of the liquid in the tank. The echo from the surface is picked up and the time between initial transmission and reception of the echo is measured. This time parameter is proportional to distance which correlates to an outage measurement of liquid level.

6.2.3.2 The transmitter should be mounted on a manhole nozzle on fixed roof tanks, and on a still pipe with a cone adaptor or wave guide on floating roof tanks.

6.2.3.3 A spot or single sensor or multisensor averaging temperature unit should be provided as a separate input to calculate standard volume when applied to hydrocarbon applications.

6.2.3.4 The radar gauge is an ideal solution to gauging aggressive chemicals, asphalt, slurries and other generally hard to measure liquid.

6.2.3.5 Minimum accuracy of 2 mm or better may be expected with proper installation and precautions taken to minimize condensing water vapor on the antenna and wave guide, because moisture will partially absorb the microwave signal.

6.2.4 The electro-ohmic tank gauges

6.2.4.1 This technology utilizes a flexible measuring element which is suspended from the top of the tank, and usually installed in a stilling well. The element comprises an insulated metallic core with a strip of conductive material on one side of the core. A continuous helix is wound around the core, but it does not come in contact with the conductive strip unless pressure is exerted on the outer jacket. The outer jacket may be teflon or another nonconductive flexible material.

As hydrostatic pressure from the liquid compresses the jacket, it forces the helix to short against the conductive strip on the core. The electro-ohmic resistance between the top of the sensor to the liquid surface converts to distance, hence providing an electrical resistance analogous to liquid level.

6.2.4.2 The minimum accuracy of electro-ohmic gauging is in the range of 3 to 6 mm.

6.2.5 Hydrostatic tank gauges

6.2.5.1 Technologically, the forces exerted by a column of liquid will vary directly with the vertical height of the liquid.

As the height increases, the pressure increases. Using this basis theorem, liquid level may be inferred as a function of pressure measurement. HTG is usually accomplished with precision pressure sensors and a temperature sensor.

6.2.5.2 Hydrostatic tank gauging is an excellent method to compute mass. Using liquid head or hydrostatic pressure measurement and tank capacity table, mass is calculated.

6.2.5.3 The precision pressure sensors can be installed directly into the side of the tank, or may be suspended into the liquid from the tank-top.

6.2.5.4 On atmospheric tanks two pressure sensors shall be used. They are located at a precise distance with respect to one another vertically. Pressurized tanks require that a third pressure sensor be placed in the vapor space above the liquid.

6.2.5.5 Accuracy of 0.1 to 0.2 percentage of full scale is expected in Hydrostatic gauging. Pressure sensors should have 0.05% to 0.1% accuracy in case of mass measurement.

6.2.5.6 Hydrostatic gauges should not be used where there is a possibility of sludge collecting at the bottom of a tank.

6.2.5.7 Gauges installed at tank bases should not be mounted on the tank bottom but should be supported from the tank wall to avoid errors due to distortion of tank bottom. The gauge datum line shall be at the same level as the datum plate used for manual gauging.

6.2.5.8 Gauges mounted at tank bases shall be provided with isolating valves to permit gauges to be removed for cleaning or repair.

6.2.6 Hybrid tank measurement systems

A Hybrid Tank Measurement System (HTMS) is a method of combining direct product level measured by an automatic tank gauge (ATG), temperature measured by an automatic tank thermometer (ATT), and pressures from one or more pressure sensors. These measurements are used, together with the tank capacity table and applicable volume and density correction tables, to provide level, temperature, mass, observed and standard volume, and observed and reference density.

The product level is directly measured by the ATG. The product temperature is directly measured by the ATT. The true (observed) density is determined from hydrostatic pressure measured by the pressure sensor(s) and the product height above the bottom pressure sensor, as measured by the ATG. Total static mass is computed by a hybrid processor from the true density and the tank capacity table. Gross observed volume, standard volume, and reference density are computed using industry practice for static calculations (see MPMS Chapter 12.1.1). The recommendations of MPMS 3.6 shall be followed.

6.3 Installation of Automatic Tank Gauges

6.3.1 General installation details

6.3.1.1 Any direct or remote reading automatic tank gauge installed on any tank which is involved in custody transfer shall be installed in strict accordance with the manufacturer’s instructions and with any applicable installation standards of the user where they do not conflict.

6.3.1.2 The accuracy of an automatic tank gauge installation is directly dependent upon the condition of the tank on which it is installed. Old and incorrectly erected tanks, particularly those with unstable bottoms, shell or roofs, will introduce an amount of error. It is recommended that all tanks proposed for automatic gauging installations, should be carefully checked for their compliance with established construction and maintenance codes and standards.

6.3.1.3 The datum plate which is normally under the gauge hatch should not be a part of the bottom of the tank. The datum plate should be attached to, and supported from, the tank shell directly underneath the manual gauge hatch at a fixed distance from the bottom, preferably not less than 5 cm. Where the tank is not so equipped, a stable reference point shall be installed at the top of the tank for outage-type manual gauge checks.

6.3.1.4 Automatic gauges should be located in close proximity to the gauging hatch, yet sufficiently distant from the suction and filling lines to minimize the disturbing effect of eddies or turbulence arising from these sources.

6.3.1.5 Either the ground-level or tank-top reading device should be at a convenient height or distance from the ground or the gauging platform to assure easy reading and to avoid reading errors.

6.3.1.6 Any movement of top horizontal tape conduit from its fixed horizontal position in any plane, will introduce appreciable error. Therefore care should be exercised that no any gauge installation will result in such movement. Fixedroof tanks with rigid gauge tape entry can cause this error as a result of roof movement. To avoid difficulty, the use of a bellows or slip joint at the point of entry is recommended.

6.3.1.7 Excessive tank turbulence or agitation caused either by high emptying-filling rates or by mechanical agitators will seriously affect automatic gauges. The result may damage the sensing element if it is an electronic surface sensing element. In these cases, it is necessary to enclose the measuring element in a gauging or stilling well, regardless of the tank type or the gauge entry point. Where the measuring element is so enclosed, the well shall be properly slotted or drilled on the sides and bottom to allow for free movement of oil into and out of the well to minimize differential gravity, pressure errors, or both.

6.3.2 Installation recommendations (tanks not in service)

6.3.2.1 In other than floating-roof tank installation, the measuring element should preferably be guided or contained in a stilling well.

6.3.2.2 In floating-roof tank installations, it is recommended that float be installed in a float well or stilling well. Attaching the actuating cable directly to the roof is not recommended, unless additional equipment is added to compensate for roof tilt error, frequently encountered. The float well should be of proper size for the float and should have a baffle or retainer in the bottom so as to prevent the float from escaping if the roof stops on its support legs when oil is pulled bellow the bottom of the well. The entry hole must be of sufficient size to allow free movement of oil into and out of the float well for equalization of liquid level. To minimize errors due to wind drift, no floating-roof, non power-operated float type gauge installation should have any tape exposed outside the tape pipe. The exposed connecting link to the float should be of stainless steel flexible cable with a maximum diameter of 1.5 mm. The top elbow or pulley should be centered over the cable hole in the float well cover.

6.3.2.3 When a gauge is installed in corrosive service, adequate provisions for sealing off or preventing vapors from entering the gauge should be included, and the last exposed sheave assembly should be of a durable corrosion resistance construction. This provision does not apply to floating-roof tanks which utilize top entry unless a floating stilling well is used.

6.3.2.4 Float guide wires should be installed plumb, properly centered, free of kinks or twists, and pulled tight under proper spring tension. They should preferably be attached to a bottom guide wire anchor. Float travel through the normal range from top to bottom of the tank should be smooth and free, with no binding or friction. The sensing element of an electronic gauge should also be checked for unimpeded movement through its range of travel.

6.3.2.5 When the gauge installation is remote reading, the installation procedure check should be made both before and after the remote transmitter is connected into the drive mechanism. The transmitter should be checked for smoothness and freedom of movement prior to installation on the automatic gauge.

6.3.2.6 All gauges must be mounted securely to the tank shell, with sufficient brackets properly attached and adequately spaced to hold the gauge in fixed relation to the tank and in proper alignment at all points.

The top horizontal tape conduit is particularly critical and must be installed to avoid any distortion arising from unequal expansion between gauge and tank shell or from roof movement. When the gauge is mounted, the tape lines, the connecting elements, and any counter weighing mechanism should center and must not touch or rub inside the gauge conduit at any point.

6.3.3 Installation recommendation (tanks in service)

6.3.3.1 On tanks in service, the attachments and bracketing to the tank shall be made without welds or under closely supervised and limited welding procedure.

6.3.3.2 In the case of the float guides, it is common practice to use guide cables which are stranded and flexible instead of more rigid solid-construction guide wires. The lower ends of the cable are secured by attaching a suspended weight of sufficient mass to hold the guide cables straight. The weight is located just above the bottom of the tank. It should be the responsibility of the inspector to assure that the weight is of sufficient mass; that it is properly suspended at the right elevation from the bottom of the tank, that the cables have been installed free of any kinks or loops which would interfere with the free operation of the float, and that tank currents are not holding the guides out of vertical. The installation must be made when the tank is almost empty, and the entire mechanism can be checked by actual trial throughout its entire range to assure freedom of movement.

6.4 Calculation of Static Petroleum Quantities

Volumetric and mass calculation of crude oil, petroleum products, and petrochemicals when contained in tanks shall be based on MPMS 12.1.1.

7. TEMPERATURE MEASUREMENT

Temperature measurement equipment which should be used on storage tank gauging are:

a) Average temperature measurement;

b) Mid-point temperature measurement;

c) Spot temperature measurement (single or multi spot).

7.1 Selection of Instrument

7.1.1 For fixed-roof, floating-roof, and vapor-tight tanks a form of averaging temperature measurement will give greater accuracy and is preferred.

7.1.2 The spirally formed type is not suitable for pressure-type tanks, but the multi-element bulb type may be used for pressure up to 3.5 bar.

7.1.3 The mid-point type shall not be used on heated tanks.

7.1.4 Spot temperature measurement may be used on fixed-roof and pressure-type and on horizontal and vertical cylindrical tanks, provided that suitable thermometer pockets are provided through the tank shell.

7.1.5 Where the spirally formed element is used, the range of relative density changes shall not be such as to affect the vertical distribution of the coils of the element.

7.1.6 Materials used in the construction of all types shall be capable of withstanding any deleterious effects of particular tank contents. Insulation materials used on the elements must be for the maximum working temperature of the tank.

7.2 Types of Temperature Measurement in Tank Gauging

7.2.1 Averaging thermometers

7.2.1.1 Three main types are available:

a) A resistance bulb assembly housed in a flexible tubular sheath designed for fitting through the tank roof and weighted or spring-loaded at the bottom. The measuring system comprises five or more individual resistance elements of varying lengths graduated according to the depth. When a temperature reading is required, the tank level is first determined and the longest element which is totally immersed is selected and connected to the indicator by means of a selector switch. The indicator thus displays the average temperature over the length of the selected element. (Fig. 6)

b) A continuous resistance element housed in a spirally formed tube which is fixed between a float on the product surface and the tank bottom. This tube is loaded to equal the product density so that it is virtually weightless and hence the spacing between turns of the spiral is always equal, and the element is linearly positioned throughout the depth of product. The float is guided by nylon ropes anchored to a top support plate and tensioned by a base weight partially resting on the tank bottom. This provides average temperature measurement from the product surface to the tank bottom. (Fig. 7, 8)

c) A continuous resistance element or bulb assembly secured along its length to a rigid beam pivoted at the base of the tank and supported at its upper end by a float at the liquid surface. (Fig. 9)

7.2.1.2 Consideration shall be given to water bottoms or sludge deposits in tanks, neither of which shall be included in the measurement of product average temperature.

7.2.1.3 All types shall be installed so that they are a minimum distance of 500 mm from the tank shell and as far as possible from heating coils and swing arms. In order to reduce or eliminate the effects of turbulence, they should be preferably on the opposite side of the tank from the inlet and outlet connections and well away from tank mixers. They should be accessible from gauge platform.

7.2.2 Mid-Point (variable height) thermometers

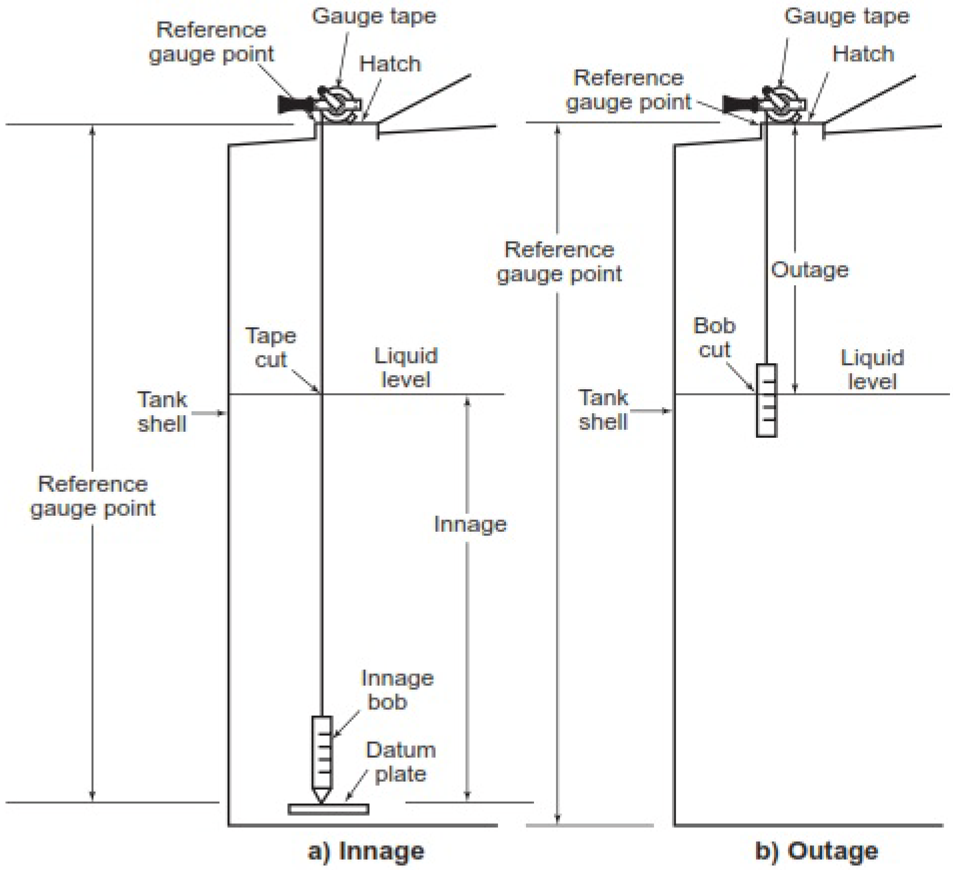
7.2.2.1 The mid-point thermometer consists of a single-point electrical resistance bulb, positioned approximately half way between the liquid surface and the bottom of the tank, by means of a float, anchor, and pulley mechanism. The thermometer bulb is maintained at mid-point regardless of the depth of product in the tank. The bulb is connected by means of cabling to local or remote indicators. (Fig. 10b)

7.2.2.2 The top, middle and bottom temperature measurement system comprises a mid-point variable height thermometer with a fixed bottom temperature sensing element and an element which is maintained just bellow the surface by the float mechanism. (Fig. 10a)

7.2.3 Thermometers for spot temperature measurement

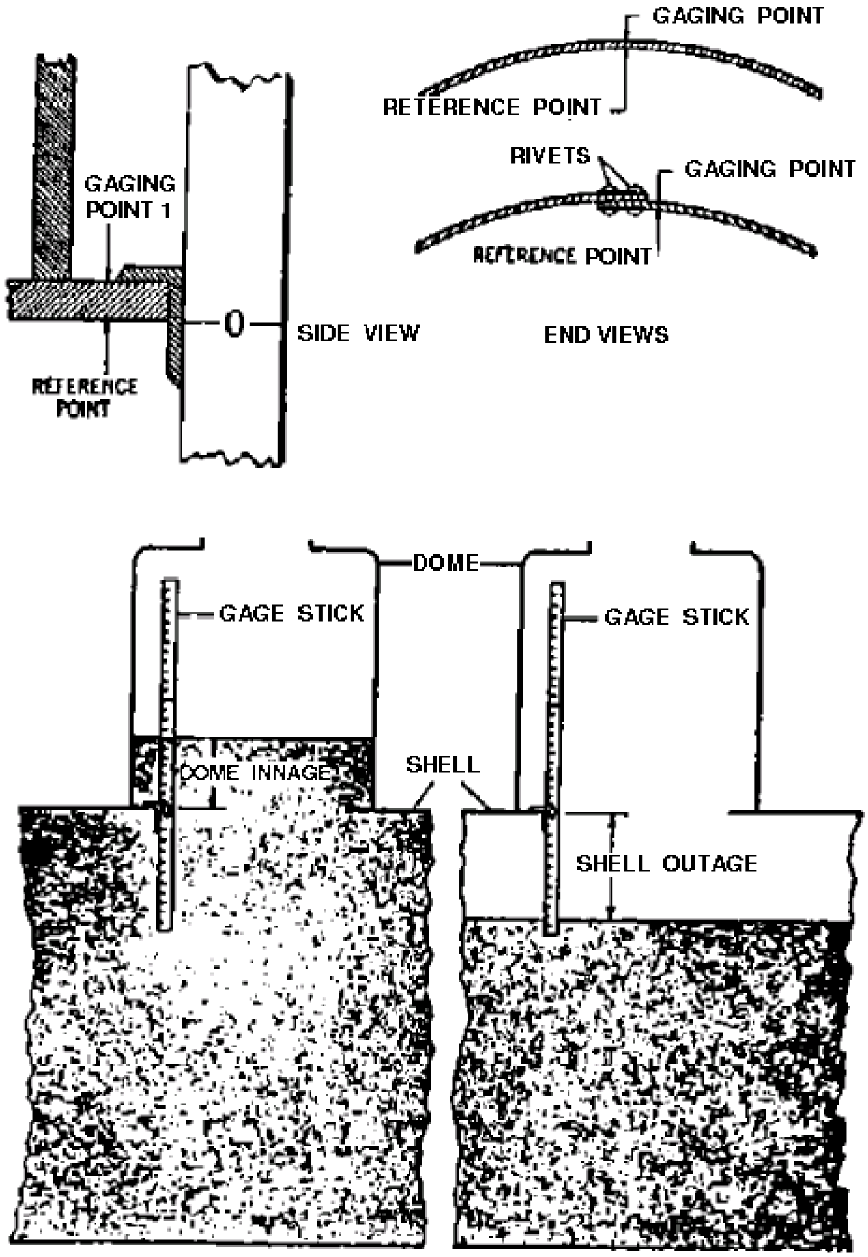
7.2.3.1 The spot type of resistance bulb consists of a wire resistance unit suitably housed and provided with leads. The housing shall be of corrosion resistant material, with leads sealed against contamination of conductors or connections.

7.2.3.2 The individual bulb shall be installed through the tank shell at the required level through conventional separable sockets. If a given tank is equipped with more than one resistant bulb in order that spot temperature may be determined at different points in the tank, a multipoint selector switch shall be used to connect the desired resistor to the meter.



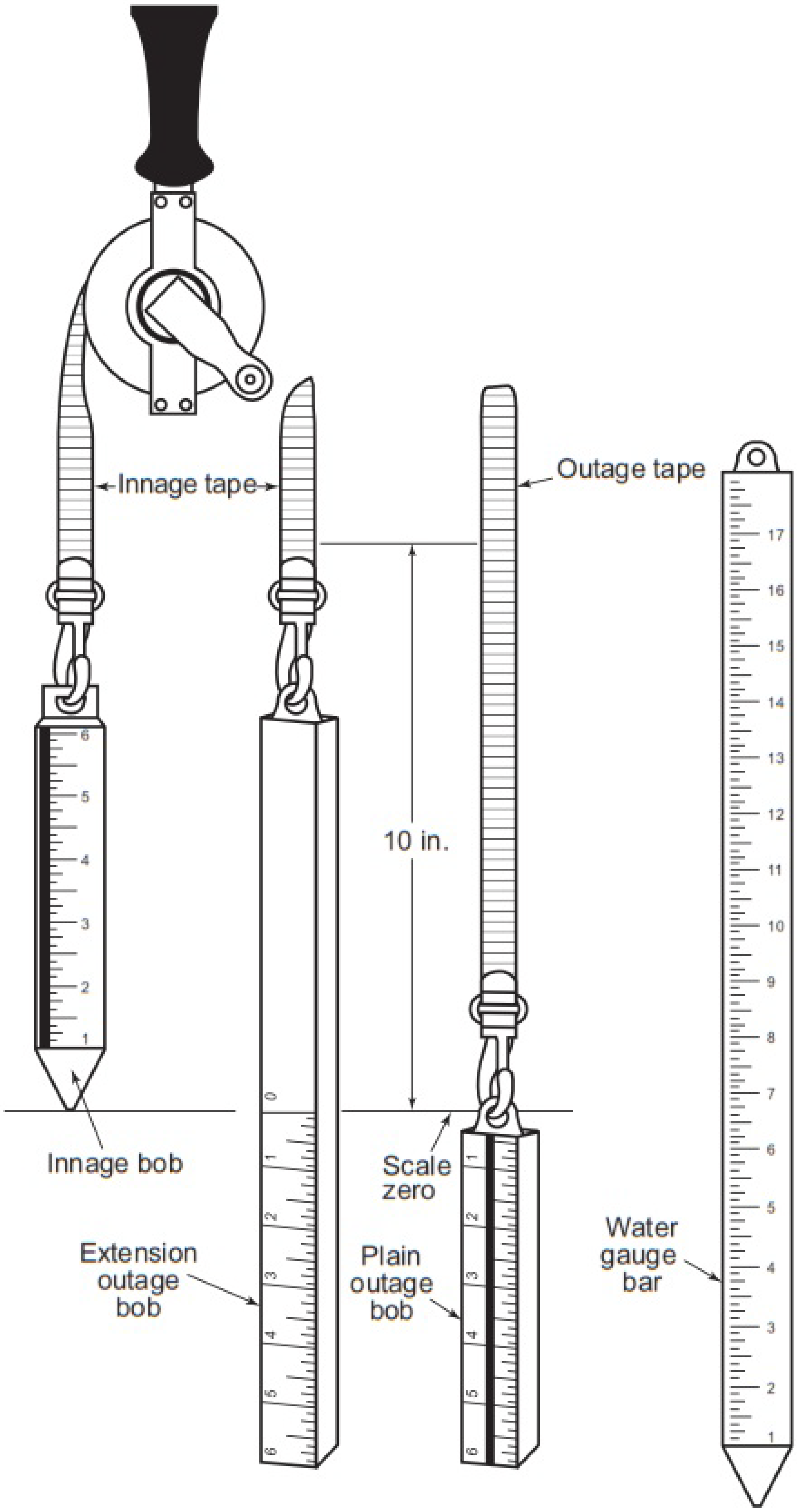
GAUGING DIAGRAM FOR CONVENTIONAL TANKS

Fig. 1



GAUGING DIAGRAM FOR TANK CARS

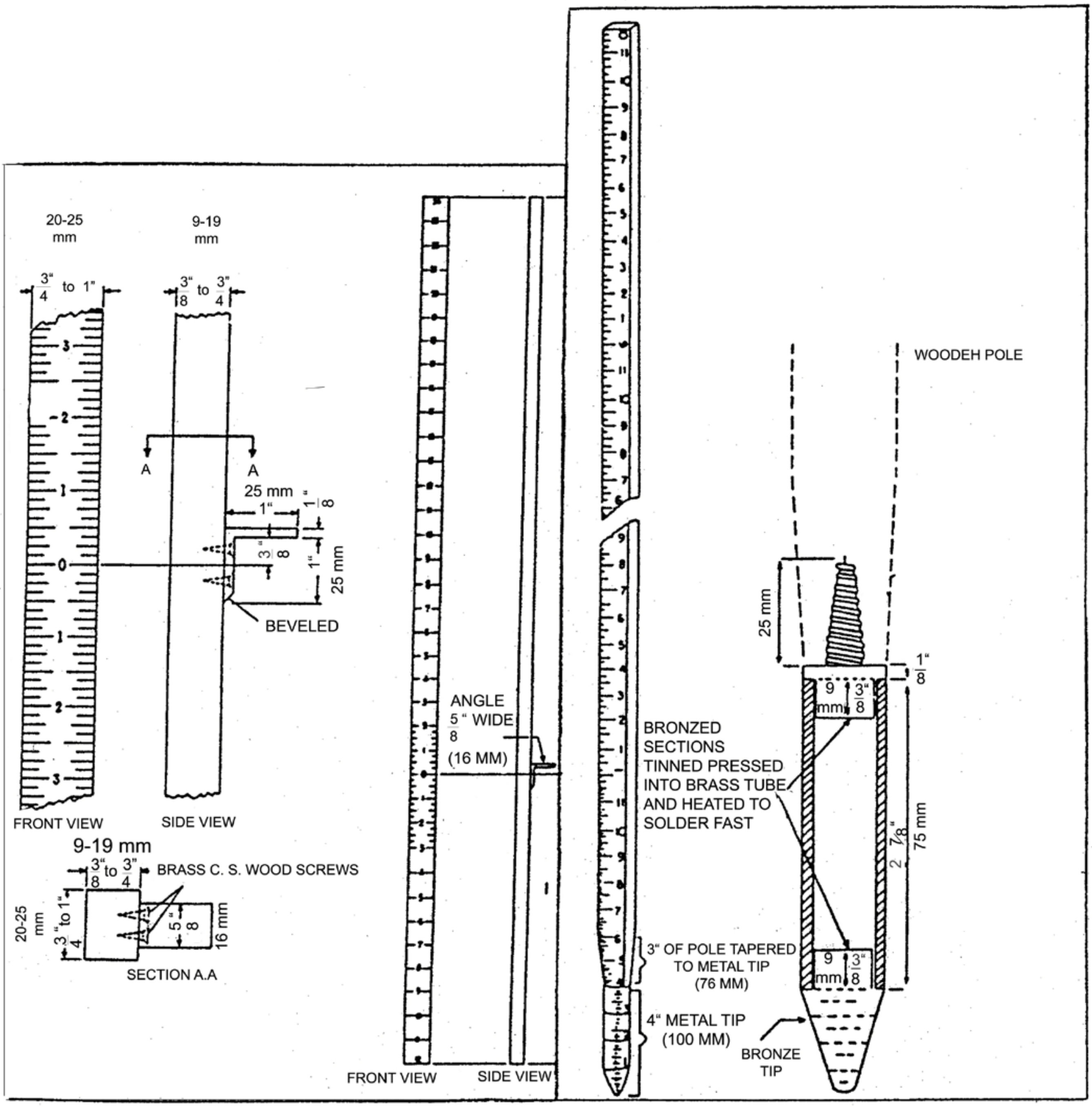
Fig. 2



(A) TYPICAL GAUGE TAPES AND BOBS **(B) TYPICAL WATER GAUGE BAR**

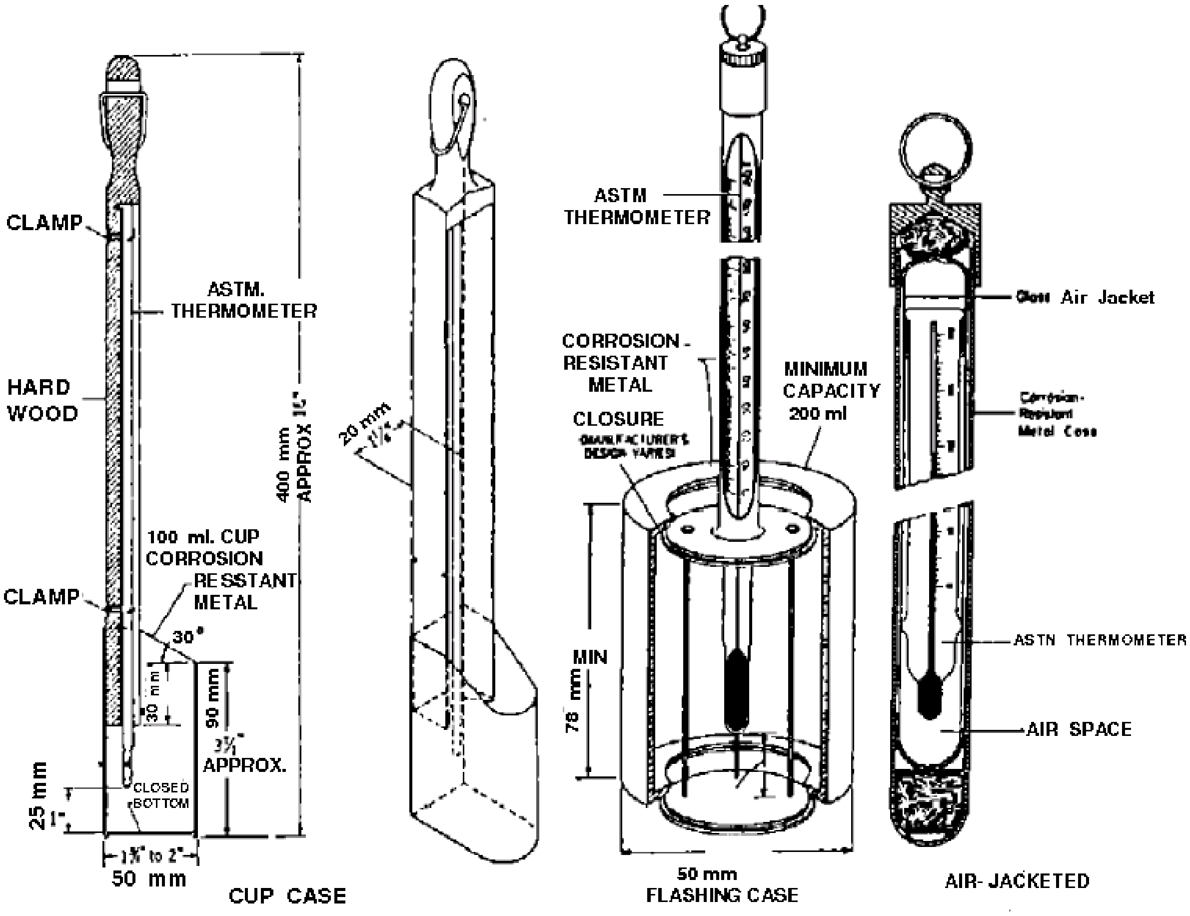
TYPICAL GAUGE TAPES AND BOBS AND TYPICAL WATER GAUGE BAR

Fig. 3



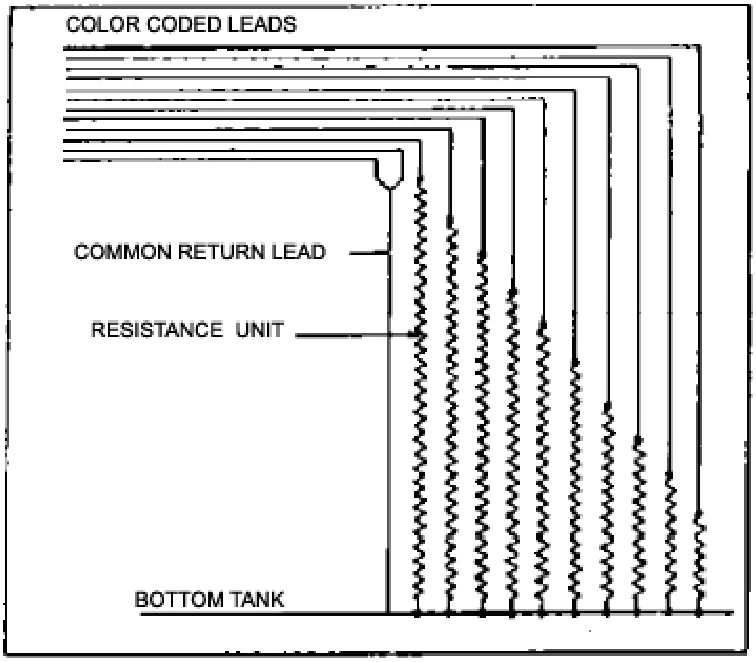
TANK CAR GAUGE STICK AND LONG POLE

Fig. 4



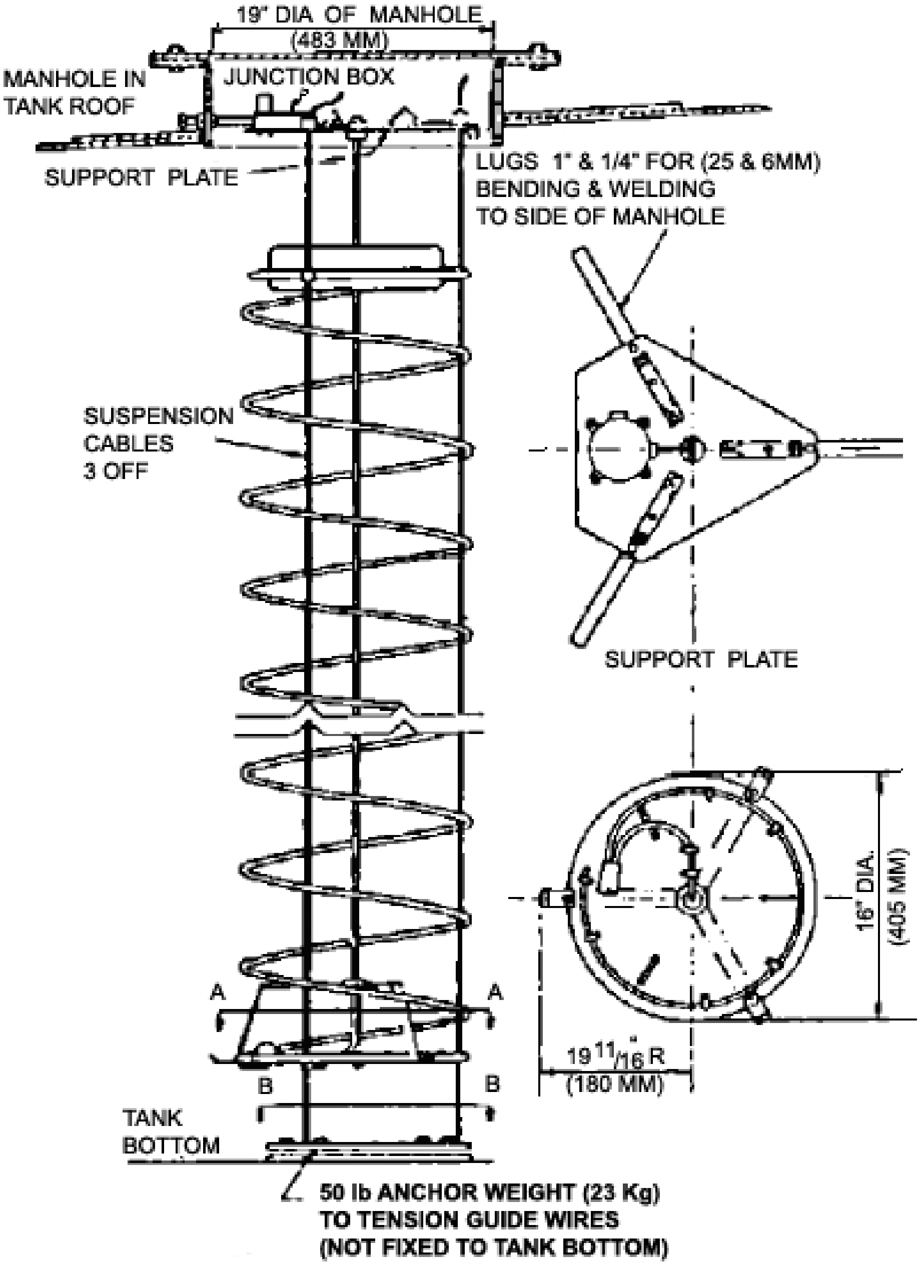
TYPICAL THERMOMETER ASSEMBLIES

Fig. 5



SCHEMATIC DIAGRAM OF AVERAGING-TYPE RESISTANCE BULB

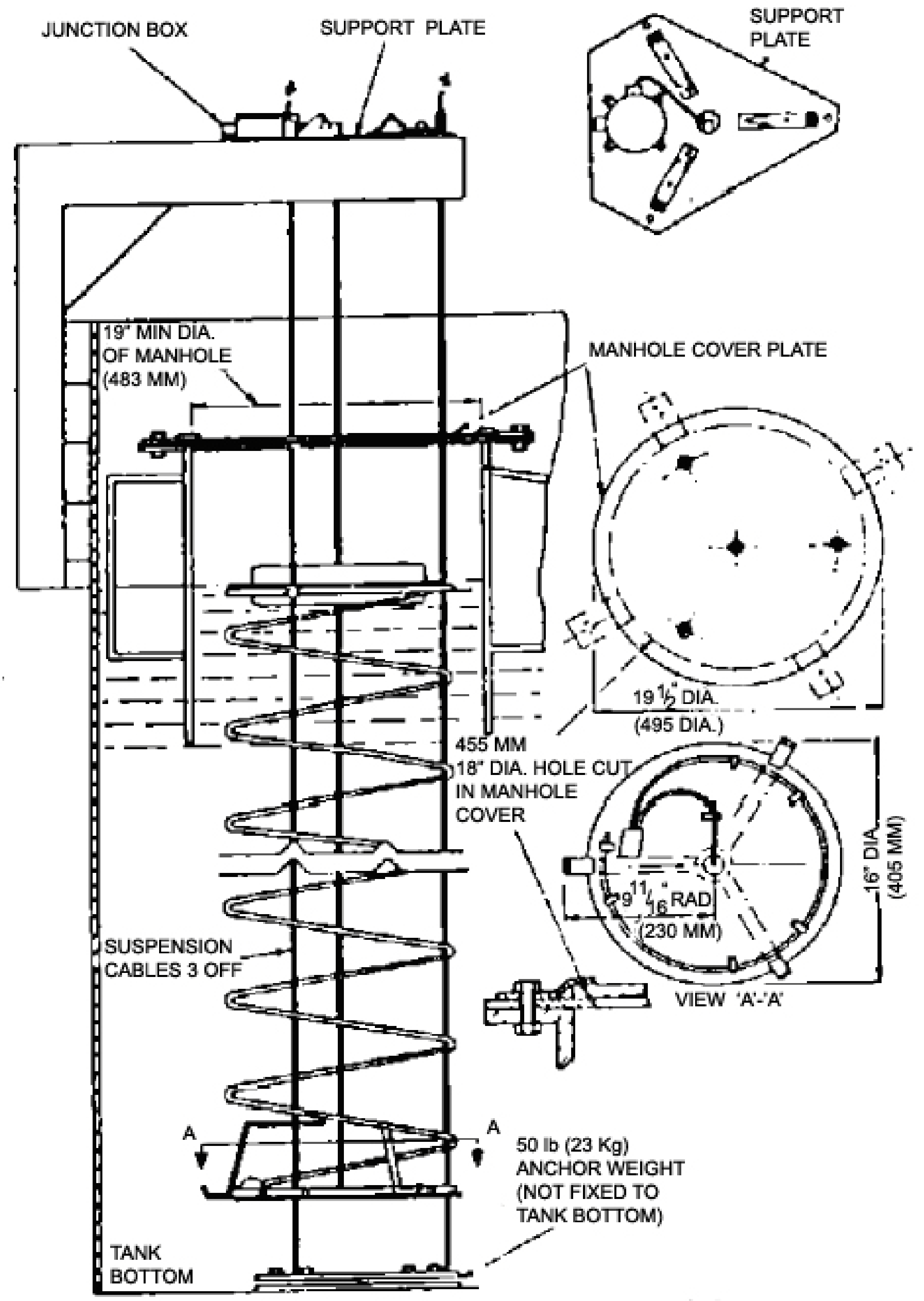
FIG. 6



Note: Function box to be compound filled

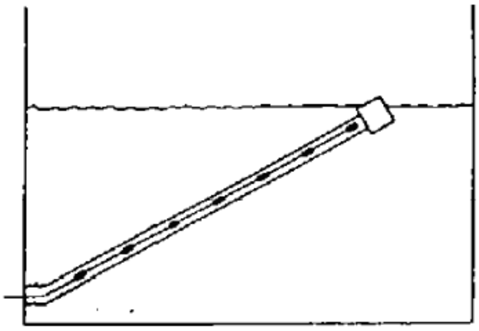
TANK AVERAGE TEMPERATURE RESISTANCE THERMOMETER ELEMENT FOR FIXED ROOF TANK

Fig. 7



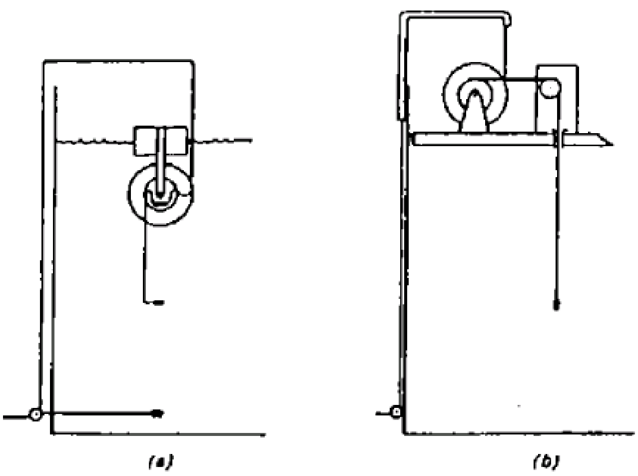
TANK AVERAGE TEMPERATURE RESISTANCE THERMOMETER ELEMENT FOR FLOATING ROOF TANK

Fig. 8



BEAM TYPE AVERAGING THERMOMETER

Fig. 9



VARIABLE HEIGHT THERMOMETERS

Fig. 10