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Petroleum and liquid petroleum products — Direct static measurements — Contents of vertical storage tanks —

Part 1:

Mass measurement by hydrostatic tank
gauging

*Pétrole et produits pétroliers liquides — Mesurage statique direct —
Contenu des réservoirs verticaux de stockage —*

Partie 1: Mesurage de masse par jaugeage hydrostatique des réservoirs



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11223-1 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 3, *Static petroleum measurement*.

ISO 11223 consists of the following parts, under the general title *Petroleum and liquid petroleum products — Direct static measurements — Contents of vertical storage tanks*:

- *Part 1: Mass measurement by hydrostatic tank gauging*
- *Part 2: Volume measurement by hydrostatic tank gauging*

Annexes A and B form an integral part of this part of ISO 11223. Annexes C and D are for information only.

Introduction

Hydrostatic tank gauging (HTG) is a method for the determination of total static mass of liquid petroleum and petroleum products in vertical cylindrical storage tanks.

HTG uses high-precision stable pressure sensors mounted at specific locations on the tank shell.

Total static mass is derived from the measured pressures and the tank capacity table. Other variables, such as level, observed and standard volumes and observed and reference densities, can be calculated from the product type and temperature using the established industry standards for inventory calculations.

The term “mass” is used in this part of ISO 11228 to indicate mass in vacuum (true mass). In the petroleum industry it is not uncommon to use apparent mass (in air) for commercial transactions.

Petroleum and liquid petroleum products — Direct static measurements — Contents of vertical storage tanks —

Part 1:

Mass measurement by hydrostatic tank gauging

1 Scope

This part of ISO 11223 gives guidance on the installation, commissioning, maintenance, validation and calibration of hydrostatic tank gauging (HTG) systems for the direct measurement of static mass in petroleum storage tanks.

This part of ISO 11223 is applicable to hydrostatic tank gauging systems which use pressure sensors with one port open to the atmosphere. It is applicable to the use of hydrostatic tank gauging on vertical, cylindrical, atmospheric storage tanks with either fixed or floating roofs.

This part of ISO 11223 is not applicable to the use of hydrostatic tank gauging on pressurized tanks.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 11223. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 11223 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of

IEC and ISO maintain registers of currently valid International Standards.

ISO 91-1:1992, *Petroleum measurement tables — Part 1: Tables based on reference temperatures of 15 °C and 60 degrees F.*

ISO 91-2:1991, *Petroleum measurement tables — Part 2: Tables based on a reference temperature of 20 °C.*

ISO 3838:1983, *Crude petroleum and liquid or solid petroleum products — Determination of density or relative density — Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods.*

ISO 3993:1984, *Liquefied petroleum gas and light hydrocarbons — Determination of density or relative density — Pressure hydrometer method.*

ISO 4266:1994, *Petroleum and liquid petroleum products — Measurement of temperature and level in storage tanks — Automatic methods.*

ISO 4267-2:1988, *Petroleum and liquid petroleum products — Calculation of oil quantities — Part 2: Dynamic measurement.*

ISO 7078:1985, *Building construction — Procedures for setting out, measurement and surveying — Vocabulary and guidance notes.*

ISO 7507-1:1993, *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks — Part 1: Strapping method*.

IEC 79-0:1983, *Electrical apparatus for explosive gas atmospheres — Part 0: General requirements*.

API¹⁾ Standard 2545, *Standard practice for gaging petroleum and petroleum products*, 1965; reapproved 1990 (ANSI/ASTM D 1085).

3 Definitions

For the purposes of this part of ISO 11223, the following definitions apply.

3.1 ambient air density: Density of ambient air at the tank side on which the pressure sensors are mounted.

3.2 ambient air temperature: Representative temperature of the ambient air at the tank side on which the HTG pressure sensors are mounted.

3.3 critical zone height

(1) Upper limit of the critical zone.

(2) Level at which one or more of the floating roof or floating blanket legs first touch the tank bottom.

3.4 critical zone: Level range through which the floating roof or floating blanket is partially supported by its legs.

3.5 dipped volume: Observed volume of product, sediment and water, calculated from the dip level and the tank capacity table.

3.6 floating-roof mass: Value of the floating-roof mass, inclusive of any mass load on the roof, manually entered in the data processor.

3.7 free water level: Level of any water and sediment that exist as layers separate from the product and lie beneath the product.

3.8 gauge pressure sensor: Sensor that uses the ambient air pressure as pressure reference.

3.9 head mass: Total measured mass between the HTG bottom sensor and the top of the tank.

3.10 head space: Space inside the tank, above the bottom HTG sensor, in which product and in-tank vapour are present.

3.11 heel space: Space inside the tank, below the bottom HTG sensor.

3.12 HTG reference point: Stable reference point from which the HTG sensor positions are measured.

3.13 hydrostatic tank gauging (HTG): Method of direct measurement of liquid mass in a storage tank based on measuring static pressures caused by the liquid head above the pressure sensor.

3.14 in-tank vapour density: Density of the gas or vapour (mixture) in the ullage space at the observed conditions (product temperature and pressure).

3.15 pin height: Lower limit of the critical zone; the level at which the floating roof or floating blanket rests fully on its legs.

3.16 pressure sensor effective centre: Point on the sensor from which the hydrostatic pressure head is measured.

3.17 product heel mass: Mass of product below the bottom HTG sensor.

3.18 product heel volume: Observed volume of product below the bottom HTG sensor, calculated by subtracting the water volume from the total heel volume.

3.19 product mass: Sum of the head mass and the product heel mass, reduced by the floating-roof mass (if applicable) and the vapour mass.

3.20 product temperature: Temperature of the tank liquid in the region where the HTG measurements are performed.

3.21 reference density: Density at the reference temperature.

3.22 reference temperature: Temperature to which reference density and standard volumes are referred.

3.23 tank average cross-sectional area: Average cross-sectional area between the elevation of the bottom HTG sensor and the dip level, over which the hydrostatic pressures are integrated in order to obtain the head mass.

3.24 tank lip: Tank bottom plate on the outside of the tank shell.

1) American Petroleum Institute.

3.25 total heel volume: Observed volume below the bottom HTG sensor, calculated from the bottom sensor elevation and the tank capacity table, corrected for observed temperature.

3.26 ullage pressure: Absolute pressure of the air (air or vapour) inside the tank, above the product.

3.27 ullage volume: Observed volume of vapour/air mixture in the ullage space, calculated as the difference between the total tank volume and the dipped volume.

3.28 vapour relative density: Ratio of molecular mass of vapour (mixture) to that of air (mixture).

3.29 water volume: Observed volume of free sediment and water, calculated from the free water level and the tank capacity tables.

4 System description

4.1 General

A hydrostatic tank gauging (HTG) system is a tank-inventory static mass-measuring system. It uses pressure and temperature inputs, the parameters of the tank and of the stored liquid to compute the mass of the tank contents and other variables as described in table 1 and annex A. See figure 1.

Determination of the other variables shown in brackets in figure 1 are not included in the scope of this part of ISO 11223.

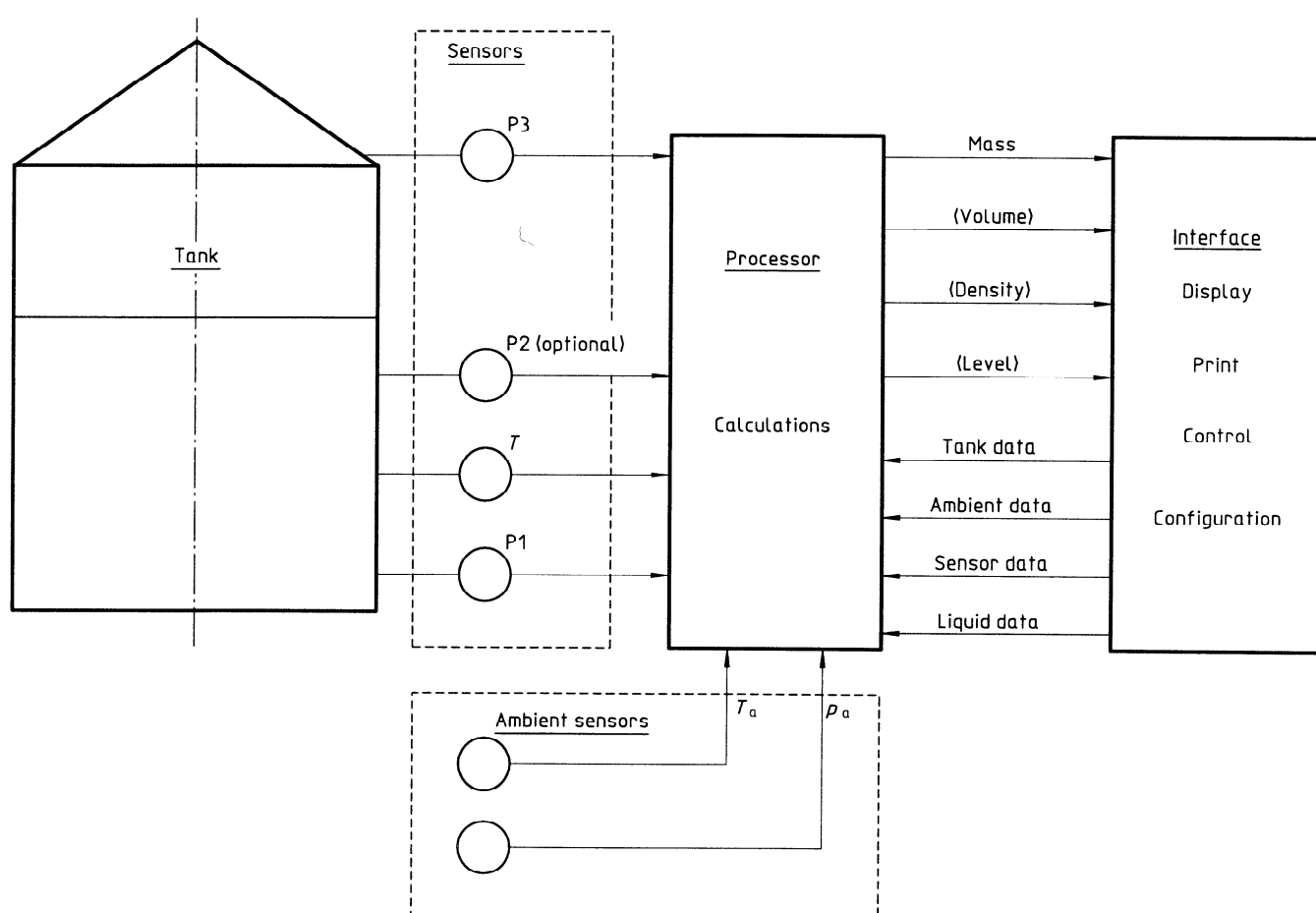


Figure 1 — HTG system — Functional diagram

4.2 Sensors

4.2.1 Pressure sensors

The hydrostatic tank gauging (HTG) system consists of up to three pressure sensors mounted on the tank shell. Additionally, temperature sensors can be included to measure the temperature of the tank contents (T) and of the ambient air (T_a). An ambient air pressure sensor (p_a) may be installed for measurements requiring high accuracy.

Sensor P1 is installed at or near the tank bottom.

Sensor P2 is the middle pressure sensor and is required for the calculation of density and levels. If the product density is known, the HTG system can operate without sensor P2 (in the absence of P2, the density data should be manually entered in the data processor). Sensor P2, if installed, should be at a fixed vertical distance above sensor P1.

Sensor P3 is the tank ullage space pressure sensor, normally installed on the tank roof. If the tank is freely vented, the HTG system can operate without P3. P3 is not required on floating-roof tanks.

4.2.2 Temperature sensors

The product temperature is needed for:

- a) calculation of volumetric expansion of the tank shell;
- b) calculation of reference density from observed density (used in HTG systems which calculate level and density as well as mass).

If the reference density is known and sensor P2 is not used, a temperature sensor may still be required for calculation of observed density.

The ambient air temperature is needed for:

- c) calculation of ambient air density;
- d) calculation of volumetric expansion of the tank shell;
- e) corrections for thermal expansion of the sensor P1 and tie bars to sensors P1 and P2.

4.2.3 System configuration

The sensor configurations vary depending on the application and data required. Some of the more common variations are as follows.

4.2.3.1 Known liquid density

Sensor P2 is normally used for the tank liquid density measurement. It is not required if the average liquid density is known.

4.2.3.2 Known ullage pressure

Sensor P3 is not required for those tanks which are vented to atmosphere (ullage gauge pressure = 0). This includes all floating-roof tanks and all fixed-roof tanks which are freely vented or which have gauging hatches that are not sealed.

NOTE 1 Tank ullage pressure on atmospheric fixed-roof tanks may differ slightly from atmospheric pressure during transfers to and from the tank. Since inventory measurements are not taken during a transfer, errors due to this effect are not significant.

If the ullage pressure is known, pressure P3 can be entered into the data processor as a constant and sensor P3 omitted on nonvented tanks.

4.2.3.3 Known tank liquid temperature

Tank liquid and ambient temperatures are used to correct for shell thermal expansion. The tank liquid temperature sensor is not required for mass measurement if the temperature of the liquid in the tank is known (ISO 4266).

4.2.3.4 Varying atmospheric conditions

Ambient temperature and pressure sensors can be used to remove secondary errors for measurements requiring high accuracy. Single measurements of ambient air temperature and pressure may be used for all tanks at the same location.

4.3 HTG data processor

A processor receives data from the sensors and uses the data together with the tank and liquid parameters to compute the mass inventory in the storage tank (see figure 1).

The stored parameters fall into four groups: tank data, sensor data, liquid data and ambient data (see table 1). Those parameters in table 1 which are required by the application should be programmed into the HTG system.

NOTE 2 The data processor can also calculate level, observed and standard volumes, and observed and reference densities. However, such calculations are not included in the scope of this part of ISO 11223.

Table 1 — Stored parameters for HTG data processing

Parameter group	Parameter	Remarks
Tank data	Tank roof type Tank roof mass Critical zone height Pin height Tank wall type Tank wall material Tank capacity table Tank calibration temperature	Fixed or floating or both Floating roofs only Floating roofs only Floating roofs only Insulated or non-insulated Two thermal expansion constants (see ISO 7507-1) Volumes at given levels Temperature to which the tank capacity table was corrected
HTG sensor data	Sensor configuration P1 sensor elevation P2 sensor elevation P3 sensor elevation	Tank with 1, 2 or 3 sensors To HTG reference point Referenced to P1 Referenced to P1
Liquid data	Liquid density Liquid expansion coefficients Free water level	If no P2 sensor See ISO 91
Ambient data	Local acceleration due to gravity Ambient temperature Ambient pressure	Obtained from a recognized source Optional Optional

When the product level drops below the level of the sensor P2, density can no longer be measured by HTG. Below this level, the last measured value of product density may be used.

The data processor may be dedicated to a single tank or it may be shared among several tanks. The processor may also perform linearization and/or temperature compensation corrections for the pressure sensors.

All variables provided by the data processor can be displayed, printed or communicated to another processor.

Computations normally performed by the data processor are described in annex A.

5 Installation

5.1 Pressure sensors

5.1.1 Tank preparation

Prior to installation of the HTG pressure sensors, it is necessary to perform the following activities.

5.1.1.1 Selection of sensor positions

All HTG pressure sensors external to the tank should be installed on the same side of the tank and, if necessary, should be protected from sun and wind.

The pressure tapings on the tank wall should be located where the product is relatively static. Product movements caused by pumping or mixing operations can produce additional static pressures.

Pressure sensor P1 is the lowest of the pressure sensors, mounted a distance H_b from the HTG reference point. Sensor P1 should be installed as low as possible on the tank, but above the level of any sediment or water.

Pressure sensor P2, if used, is located a vertical distance H above sensor P1. The maximum P2-to-P1 vertical distance is not specified, the restricting factor being that when the liquid level drops below sensor P2, the observed density can no longer be measured. The minimum P2-to-P1 vertical distance depends on the requirements for density measurement accuracy.