International Standard

ISO 4266-6

Second edition
2024-10

Petroleum and liquid petroleum products — Measurement of level and temperature in storage tanks by automatic methods —

Part 6: Measurement of temperature in pressurized storage tanks (non-refrigerated)

Pétrole et produits pétroliers liquides — Mesurage du niveau et de la température dans les réservoirs de stockage par méthodes automatiques —

Partie 6: Mesurage de la température dans les réservoirs de stockage sous pression (non réfrigérés)

Reference number
ISO 4266-6:2024(en)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, Subcommittee SC 2, *Measurement of petroleum and related products*.

This second edition cancels and replaces the first edition (ISO 4266-6:2002), which has been technically revised.

The main changes are as follows:

— normative references have been updated;

— in 4.3.2, it has been clarified that the level should be measured and recorded simultaneously with the temperatures;

— in 7.2.1, equipment has been clarified;

— in 9.4.2, subsequent verification requirements have been clarified.

A list of all parts in the ISO 4266 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Petroleum and liquid petroleum products — Measurement of level and temperature in storage tanks by automatic methods —

Part 6: Measurement of temperature in pressurized storage tanks (non-refrigerated)

1 Scope

This document gives guidance and recommendations on the selection, accuracy, installation, commissioning, calibration and verification of automatic tank thermometers (ATTs) in fiscal/custody transfer applications, in which the ATT is used for measuring the temperature of petroleum and liquid petroleum products stored in pressurized storage tanks.

This document is not applicable to the measurement of temperature in caverns or in refrigerated storage tanks.

2 Normative reference

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1998 (all parts), *Petroleum industry — Terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1998 (all parts) and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
automatic tank thermometer
ATT
instrument that continuously measures temperature in storage tanks

Note 1 to entry: An ATT, which can also be known as an automatic tank temperature system, typically includes precision temperature sensors, field-mounted transmitters for electronic signal transmission, and receiving/readout device(s).

3.2
resistance temperature detector
RTD
electrical temperature-sensing element commonly used to measure the temperature of the contents of a storage tank

3.3
single-point automatic tank thermometer
spot automatic tank thermometer
measures the temperature at a particular point in a tank by the spot temperature element

3.4
multiple-point automatic tank thermometer
consisting of multiple (usually three or more) spot temperature elements to measure the temperature(s) at selected liquid level(s)

Note 1 to entry: The readout equipment should average the readings from the submerged temperature elements to compute the average temperature of the liquid in the tank, and can also display the temperature profile in the tank.

3.5
multiple-point averaging automatic tank thermometer
where the readout equipment selects the individual, spot temperature element(s) that are submerged in the liquid to determine the average temperature of the liquid in the tank

3.6
variable-length averaging automatic tank thermometer
consisting of several temperature elements of varying length, with all the elements extending upwards from a position close to the bottom of the tank, and where the readout equipment selects the longest, completely submerged temperature element to determine the average temperature of the liquid in the tank

3.7
temperature transmitter
instrument that typically provides electrical power to the temperature element(s), converts the temperature measured by the element(s) to an electrical or electronic signal, and transmits the signal to a remote readout

Note 1 to entry: A local readout can be provided. Often, the function of the temperature transmitter is provided by the level transmitter of the automatic level gauge (ALG).

4 Precautions

4.1 Safety precautions

When using ATT equipment, it is expected that any relevant International Standards and government regulations on safety and material compatibility precautions are followed when using ATT equipment. In addition, the manufacturer's recommendations on the use and installation of the equipment should be followed. It is presupposed that all regulations covering entry into hazardous areas are observed.

4.2 Equipment precautions

4.2.1 All ATT equipment should be capable of withstanding the pressure, temperature, operating and environmental conditions likely to be encountered in service.

4.2.2 ATTs should be certified for use in the hazardous-area classification appropriate to their installation.

4.2.3 Measures should be taken to ensure that all exposed metal parts of the ATT have the same electrical potential as the tank.

4.2.4 All parts of the ATT in contact with the product or its vapour should be chemically compatible with the product, to avoid both product contamination and corrosion of the ATT.

4.2.5 All ATT equipment should be maintained in a safe operating condition and the manufacturer's maintenance instructions should be complied with.

4.3 General precautions

4.3.1 The general precautions given in 4.3.2 to 4.3.6 apply to all types of ATTs and should be observed where they are applicable.

4.3.2 When measuring product temperatures and vapour pressure, product levels should be measured and recorded simultaneously, or as close together as practical. The level should be representative of the tank contents and should be measured as described in ISO 4266-3.

4.3.3 Temperatures measured for bulk transfer should be recorded when they are taken, unless the remote readout equipment of the ATT automatically records the temperatures periodically.

4.3.4 The same general procedures should be used to measure a tank temperature before product transfer (opening gauge) and after product transfer (closing gauge).

4.3.5 ATTs should provide security to prevent unauthorized adjustment or tampering. ATTs used in fiscal/custody transfer applications should provide facilities to allow sealing for calibration adjustment.

4.3.6 The design and installation of ATTs can be subject to the approval of the national measurement organization, who will normally have issued a type or pattern approval ("Type Approval") for the design of the ATT for the particular service for which it is to be employed. Type approval is normally issued after an ATT has been subjected to a specific series of tests and is subject to the ATT being installed in an approved manner. Type approval tests may include the following: visual inspection, performance, vibration, humidity, dry heat, inclination, fluctuations in power supplies, insulation resistance, electromagnetic compatibility and high voltage.

5 Accuracy

5.1 General

The accuracy of petroleum temperatures taken by the ATTs should be consistent with the accuracy of the levels taken by the automatic tank-level gauging system so that the overall accuracy of the standard volume measurement is not seriously degraded.

5.2 Intrinsic error of ATTs

The intrinsic error of the ATT, i.e. the accuracy of the ATTs when tested under controlled conditions as specified by the manufacturer, can be a major component of the uncertainty of the temperature measurement of the ATT as installed.

NOTE The temperature elements and field transmitters used for fixed, automatic tank temperature measurement are calibrated prior to installation. The transmitters normally do not provide field calibration adjustments.

5.3 Calibration prior to installation

5.3.1 General

ATTs used in fiscal/custody transfer applications can be calibrated/verified either as a system or by components. It is presupposed that the certified reference device used to calibrate the ATT is traceable to national standards. The certified reference should be provided with a calibration record.

5.3.2 ATT calibrated as a system

If verified as a system, the temperature reading of the ATT readout should agree with that of the thermostatically controlled reference bath or oven temperature within 0,25 °C at a minimum of three test temperatures spanning the anticipated working range of the ATT.

5.3.3 ATT calibrated by components

If the ATT is verified by components:

a) the temperature equivalent of the measured resistance should agree with the bath temperature within 0,20 °C at each temperature;

b) the temperature transmitter/converter and the ATT readout should be checked using precision resistors or a recently calibrated thermal calibrator. The ATT readout should agree with the temperature equivalent of the resistors or calibrator within 0,15 °C at each temperature.

5.3.4 Multiple-point ATTs

The required accuracy for each spot temperature sensor should be as given in 5.3.2 or 5.3.3, depending on the method used.

5.3.5 Uncertainty of the reference

The uncertainty of the reference should not exceed ±0,05 °C.

5.4 Error caused by installation and operating conditions

The total error of the ATT in fiscal/custody transfer can be affected by the installation and by variations in the operating conditions.

NOTE 1 The accuracy of an ATT depends on the following:

— the number of temperature-sensing elements;

— the location of the temperature-sensing elements.

NOTE 2 The tank content's temperature can be subject to stratification which varies with:

— tank mixing;

— multiple sources of supply;

— viscosity of the liquid in the tanks;

— tank insulation, and

— tank shape (e.g. long, horizontal tanks or “bullets”)

NOTE 3 Temperatures in large tanks (i.e. 750 m^3 or larger) can be stratified due to a change of incoming liquid. Stratification due to high viscosity of the product is uncommon in pressurized tanks, since these products generally have a low viscosity.

5.5 Overall accuracy

5.5.1 General

The overall accuracy of temperature measurement by the ATT, as installed, is limited by the intrinsic error of the ATT equipment (temperature-sensing element, transmitter and readout), the effect of installation methods, and the effect of the operating conditions.

5.5.2 Use of ATT for fiscal/custody transfer purposes

An ATT system should be considered suitable for fiscal/custody transfer services if the ATT system meets the following field verification tolerances.

The ATT should meet the calibration tolerances prior to installation (see 5.3).

Including the effects of installation methods and changes in operating conditions, the ATT should meet the field verification tolerance (see 9.2.2 and 9.3.2).

The remote readout, if used, should meet the recommendations of ISO 4266-6 (see Clause 10).

6 Selection of ATTs

6.1 General

Copper or platinum temperature element bulbs, i.e. resistance temperature detectors (RTDs), are normally used for this application. Two types of ATT elements are in general use for pressurized storage tanks:

— single-point or spot ATT (see 3.3);

— multiple-point ATT (see 3.4).

Other types of ATT elements that provide comparable performance may be used.

Variable-length ATTs are not generally recommended because they will produce an erroneous average value of the product temperature in non-cylindrical tanks if temperature stratification is present. The linear distribution of the averaging elements requires a linear tank geometry.

The selection of a suitable ATT should be made based on the following criteria:

a) the accuracy required;

b) the operating conditions, which can affect the accuracy (e.g. expected product temperature stratification);

c) the minimum level in the tank at which temperature measurement is required;

d) environmental conditions;

e) number, type and size of the tanks;

f) available tank entries for new or existing tanks;

g) requirement for local and remote readout, signal transmission, and cabling;

h) the geometry of the tank (e.g. variable-length averaging ATTs should not be selected for non-linear tanks).

6.2 ATTs for fiscal/custody transfer purpose

Tanks using an automatic method to determine temperature in fiscal/custody transfer may be fitted with single-point ATTs or multiple-spot ATTs. Sometimes, a single-point ATT can be considered adequate for non-refrigerated LPG storage tanks. However, if product temperature stratification is expected, a multiple-spot ATT should be considered.

When multiple-spot ATTs are used, special care should be taken concerning the averaging algorithm, since the shape of a pressurized tank is most often non-cylindrical. The computing of an average product temperature should take the tank shape into consideration, and the values from each individual temperature element should be weighted.

NOTE Generally, pressurized tanks are used for storage of low viscosity products which have less temperature stratification. Therefore, a single point temperature measurement can be sufficiently representative.

7 Description of ATT equipment

7.1 Introduction

Most above-ground bulk storage tanks are equipped with at least one local direct-reading thermometer mounted in a fixed thermowell. This local thermometer is not considered as part of the ATT and should not be used for fiscal/custody transfer temperature determination.

7.2 Electrical temperature elements

7.2.1 General

Copper or platinum electrical-resistance detectors (RTDs) are normally used for temperature measurement for fiscal/custody transfer because of their high accuracy and stability. Other types of temperature elements (e.g. thermocouples, thermistors, semiconductors, fibre optics) are available. Unless calibrated and meeting the verification tolerance given in Clause 5, their accuracy is not considered suitable for fiscal/custody transfer services.

8 Installation of ATTs

8.1 General

The temperature elements of an ATT should be mounted in the tank in relation to the position of the inlet and outlet connections so that the effect of turbulence on the mounting of the element is minimized. They should, where possible, be located on the shaded side of the tank and should be accessible.

8.2 Single-point or spot temperature elements

Single-point or spot temperature elements are normally installed in a pressure-tight thermowell through the tank shell, projecting at least 1 m into the tank to reduce any heat transfer effect through the thermowell. The spot temperature element for the liquid content should be located at an elevation of at least 1 m above the tank bottom surface.

Another spot temperature element for the vapour temperature should be located above the maximum fill height.

8.3 Multiple-point temperature elements

Multiple-point temperature elements are typically installed in a pressure-tight thermowell at equidistant intervals (at approximately 3 m). The lowest element used for the average tank temperature calculation is usually located at approximately 1 m from the bottom of the tank. Where the tank is operated at a level lower than 1 m, an extra temperature element can be located at a level as low as practical but it should only be used in this condition. The temperature element(s) can also measure the vapour temperature when the element(s) is (are) above the liquid surface.

In pressurized tanks, the spot elements may be installed in thermowells extending through the tank shell. All temperatures are generally measured and transmitted to a central temperature readout device with computing ability integral to the ALG system. The temperature-readout device should average only the measurements from the submerged elements. For non-cylindrical tanks, the averaging algorithm should be able to calculate a weighted average, which corresponds to the shape of the tank. Alternatively, the device can transmit the individual temperature of the submerged elements to provide a vertical profile of temperature.

8.4 Moveable spot temperature element

A spot temperature element attached to the displacer of a servo-operated ALG is driven through the liquid, stopping at various depths to determine the average tank temperature. Adequate time should be provided at

each measurement location to ensure that thermal equilibrium is reached. To establish the average product temperature, the averaging algorithm should take into consideration the non-linear geometry of the tank.

NOTE A moveable spot temperature element does not provide continuous measurement.

8.5 Other methods

Other methods may be used to meet the requirements of average tank-temperature measurements given in 8.1 to 8.4

8.6 Thermowells for electronic temperature elements

Thermowells for fixed temperature elements should extend through the tank shell for at least 1 m to reduce errors due to temperature differences between the liquid in the tank and ambient temperature. The thermowell material should be compatible with the liquid and designed for the specified pressure.

The thermowells should be located as far as possible from the tank inlet and outlet.

8.7 Thermowells for verification purposes

Since verification of an installed multiple-point ATT normally cannot be performed when the tank is pressurized, a separate thermowell installed close to the thermowell of the ATT may be used. This thermowell may be used when manually verifying the measurement accuracy of the ATT with a portable electronic thermometer.

NOTE Safety requirements often preclude installation of a separate thermowell on pressurized storage tanks, and therefore this thermowell is often not available.

9 Calibration and field verification of ATTs

9.1 General

The ATT, including the temperature element(s), the transmitter and the readout, selected for temperature measurement for fiscal/custody transfers, should meet the calibration tolerances given in Clause 5. It is presupposed that the calibration reference for an ATT is traceable to applicable national standards.

NOTE 1 The temperature elements and field transmitters used for fixed, automatic tank temperature measurement are calibrated prior to installation. The transmitters normally do not provide field calibration adjustments.

NOTE 2 The purpose of this procedure is to verify the adequacy of the calibration and the accuracy of the ATT (including the temperature elements, the transmitter, and the local/remote readout) as installed.

When an ATT is checked or calibrated by manual temperature measurement, the manual temperature measurement should be performed in accordance with ISO 4268. The uncertainty of the field calibration reference should not exceed 0,1 °C (with any necessary calibration corrections applied).

9.2 Calibration of single-point temperature element ATTs used for fiscal/custody transfer purpose

9.2.1 Calibration prior to installation

Prior to installation, ATTs should be calibrated under controlled conditions (i.e. in the factory or in a testing laboratory), in one of the two ways described below.

NOTE Applicable national standards can apply.

a) The ATT (including the temperature sensor, the temperature transmitter/converter, and the readout) as a whole, may be calibrated with constant temperature baths, at three or more temperatures covering

the operating range. The bath temperatures should be measured by reference thermometer(s) (see 5.3.2 for the required accuracy).

b) Alternatively, the components of the ATT may be separately calibrated. Measure the resistance of the temperature sensor in the bath. Separately, use precision resistors, or a thermal calibrator to simulate temperature input to the temperature transmitter/converter and readout of the ATT (see 5.3.3 for the required accuracy).

9.2.2 Initial field verification

9.2.2.1 Verification by components

9.2.2.1.1 Temperature element

The verification of single-point elements normally cannot be performed with the elements installed in a pressurized storage tank, unless a separate thermowell is available (see 8.3). The normal practical procedure is therefore to verify the measurement each time the tank is depressurized, i.e. when the tank is out of service or by removal of the single-point ATT for verification outside the tank. When verified outside the tank, the procedure in 9.2.1 should be followed.

When the ATT temperature elements are verified as installed with the tank depressurized but containing liquid (e.g. during hydrostatic tank testing), the following procedure should be followed.

Use a recently calibrated portable electronic thermometer to verify the measurement by the temperature element. Lower the thermometer to the depth at which the element is located and move the thermometer up and down (over a range of approximately 300 mm) until the temperature is stable. The temperature measured by the RTD temperature sensor should agree with the temperature measured by the calibrated portable electronic thermometer within 0,4 °C.

9.2.2.1.2 Temperature transmitter

The ATT, excluding the temperature element, can be verified by using a temperature calibrator (e.g. precision resistors or a thermal calibrator) to simulate temperature input at three or more temperatures covering the expected tank operating temperatures. The ATT readout should agree with the temperature equivalent of the resistors within 0,25 °C at each temperature.

9.2.2.2 Verification as a system

The following procedure may be followed if the tank is depressurized or if a separate thermowell is available.

As an alternative to separate calibration checks of the temperature element and the transmitter, a portable electronic thermometer, calibrated immediately prior to verification, may be used to verify the entire ATT. As it is sometimes not possible to position the thermometer close to the temperature element, and slight horizontal temperature stratification that can occur, it is possible that the measurements do not agree completely. Generally, for ambient storage tanks, if the sensing element of the portable electronic thermometer can be placed within 1 m of the fixed temperature element, calibration by a portable electronic thermometer should be acceptable.

The temperature measured by the ATT system (temperature sensor, temperature transmitter/converter and readout) should agree with the temperature measured by the calibrated portable electronic thermometer within 0,5 °C.

9.3 Calibration of upper, middle and lower or multiple-point ATTs

9.3.1 Calibration prior to installation

Each point (i.e. temperature-sensing element) of the ATT should be checked following the calibration procedure described in 9.2.1, for single-point or mid-level ATTs (see 5.3.4 for the required accuracy).