TECHNICAL REPORT

ISO/TR 7507-6

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Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks —

Part 6:
Recommendations for monitoring, checking and verification of tank calibration and capacity table

Pétrole et produits pétroliers liquides — Jaugeage des résevoirs cylindriques verticaux —

Partie 6: Recommandations relatives à la surveillance, au contrôle et à la vérification du jaugeage des réservoirs et des tables de jaugeage

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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.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 7507-6, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 3, *Static petroleum measurement*.

It was decided to publish this document in the form of a Technical Report (type 2) in order to gain wider experience with the use of the recommendations. It is envisaged that, when ISO 7507-1 is reviewed, that these recommendations will be included in it and this Technical Report withdrawn.

ISO 7507 consists of the following parts, under the general title *Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks*:

— *Part 1: Strapping method*

— *Part 2: Optical-reference-line method*

— *Part 3: Optical-triangulation method*

— *Part 4: Internal electro-optical distance-ranging method*

— *Part 5: External electro-optical distance-ranging method*

— *Part 6: Recommendations for monitoring, checking and verification of tank calibration and capacity table*

Annex A forms an integral part of this part of ISO 7507. Annex B is for information only.

Introduction

Vertical cylindrical tanks are a type of tank in general use throughout the world for the storage of petroleum and petroleum products. Measurement of liquid levels and the use of the tank's capacity table permit the assessment of volume of the liquid held in store or transferred. Vertical cylindrical tanks, in common with other measurement devices, are subject to alterations in their calibration. Previously, such alterations were considered insignificant and their magnitude had never been seriously assessed. This part of ISO 7507 is based on the results of an investigation carried out in the United States of America ([1] in annex B).

Data currently available indicates that tanks are subject to a primary settlement which generally occurs during the first 5 years to 10 years of service. Secondary settlement can also occur but appears to spread over the next 10 years to 20 years of the tank's life. Tanks can undergo gradual changes in diameter, tank plate thickness and tilt throughout their service life. These factors affect the calibration of the tank and consequently the accuracy of any quantity assessments made using the tank capacity tables.

Petroleum and liquid petroleum products — Calibration of vertical cylindrical tanks —

Part 6:
Recommendations for monitoring, checking and verification of tank calibration and capacity table

1 Scope

This part of ISO 7507 gives guidance on monitoring the accuracy of the calibration and the tank capacity table of a vertical cylindrical tank.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 7507. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 7507 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

3 Definitions

For the purposes of this part of ISO 7507, the terms and definitions given in ISO 7507-1 apply.

4 Recalibration and recalculation

The assessment of the nature and extent of various factors which can influence changes in the capacity of the tank determine whether a tank should be recalibrated or its tank capacity table recalculated. It is not practicable to indicate definitively all those factors which would require either recalibration or recalculation.

Recalibration is the process of measuring the tank when it has been established that the original measurements no longer define the tank dimensions accurately. In these circumstances, the tank should be remeasured completely and a revised tank capacity table calculated from the new measurements.

Recalculation of the tank capacity table is required when operating variables, such as product density, average storage temperature, or reference height, are altered; or modification of the deadwood occurs. In these circumstances, the recalculation of the tank capacity table is based on previously measured tank dimensions.

5 Criteria for deciding significance of change

In order to establish acceptance limits for change in the measurement and the operating variables which affect a tank's capacity, it is necessary to decide the overall variation in tank volume that is significant.

As a general rule, a variation in tank volume of 0,01 % or greater should be considered significant.

A range of 0,01 % to 0,05 % change in the tank capacity is given in tables 1 to 5. Tables 1, 2 and 3 provide criteria for recalibration, whilst tables 4 and 5 provide criteria for recalculation.

In the case of tilt, the recommended criterion is a change of 10 mm/m of tank height.

> NOTE 1 - Although this will affect the apparent tank capacity to only a relatively minor extent, the change in tilt is considered more important than the capacity effect. A significant degree of tilt can be an indication of serious structural problems in the tank's foundations and should be investigated.

6 Recalibration of the tank

6.1 Factors influencing the need for recalibration

Recalibration of a tank may be required if any of the dimensions or characteristics of the following alter:

a) tank diameter;

b) tank plate thickness;

c) tank tilt;

d) deadwood;

e) tank reference height; or

f) repairs undertaken to the tank structure which significantly alter its capacity.

6.2 Recommendations for assessment of need for recalibration

The following recommendations are a basis for deciding whether recalibration is required:

a) Verification of the bottom course diameter, plate thickness and tank tilt should be carried out every 5 years. If the changes in measured dimensions exceed the minimum level of significance (see clause 5), the recalibration should be undertaken.

b) A total recalibration should be undertaken every 15 years as a matter of routine, even if the 5 yearly verification checks do not show any variation within the limits given in clause 5.

6.3 Structural alterations to tanks

Recalibration may be required if structural alterations are made to the tank. Examples of such alterations are:

a) extensive changes to the deadwood of the tank;

b) alterations to the reference height by alterations to the height of the dipping datum-point;

c) repair work to the bottom plating.

7 Recalculation of the tank capacity tables due to operational changes

7.1 Factors which generate a need for recalculation

There are several factors which, when altered, generate a need for recalculation of the tank capacity tables. The first 2 are operational factors, the others mechanical changes:

a) Changes in the average operating temperature of the tank shell.

b) Changes in the density of the product stored in the tank.

c) Alterations to the vertical position of the dipping datum-point.

NOTE 2 - This may require recalculation of the tank capacity tables (see 7.5).

d) Alterations to the apparent mass in air of the floating roof.

e) Simple changes to tank deadwood.

7.2 Tank shell temperature

Tank capacity tables are calculated at a standard temperature which is indicated on the printed tables.

Unless the tank capacity tables are included in a computerised oil volume calculation procedure which includes a routine to calculate the effect of temperature on the capacity of the tank, alterations in the average operating temperature of the tank shell may require that the tank capacity tables be recalculated. Such recalculations should be carried out in accordance with annex A or ISO 7507-1:1993.

Table 4 shows variations in tank capacity due to variations in tank shell, ambient air and liquid temperatures to assist in determining whether a tank requires recalculation.

7.3 Density changes

Tank capacity tables are calculated on the basis of either the tank in an unstressed condition, i.e. empty of liquid, or containing liquid of a stated liquid density. The basis is indicated in the printed tank capacity tables.

Unless the tables are included in a computerised volume calculation procedure which includes a routine to calculate the effect of varying density of the liquid contained in the tank, then any alteration in the density of the liquid contained in the tank can require that the tank capacity tables be recalculated. Such recalculations should be carried out in accordance with ISO 7507-1.

7.4 Floating roof corrections

Floating roof corrections are affected by the density of the product in which the roof is floating. If the floating roof correction has been incorporated in the tank capacity tables then consideration should be given to recalculation if the density of the liquid stored in the tank is altered. In these circumstances, the effect of the variations in liquid density may be significant if the roof is grounded.

Recalculation should also be undertaken if there have been changes to the apparent mass in air of the floating roof.

7.5 Changes in dipping datum-point

Alterations to the vertical position of the dipping datum-point may require either a complete recalibration or a complete recalculation.

If the datum-point has been moved downwards then, unless the details of the bottom survey have been retained, it will be necessary to recalibrate the tank bottom so that the capacity below the datum-point can be recalculated.

If the datum-point has been moved upwards, the tank capacity tables may be recalculated by altering the vertical height between the calibration datum-point and the dipping datum-point; see ISO 7507-1.

7.6 Changes to tank deadwood

Corrections for minor changes in tank deadwood may be effected by recalculation of the tank capacity table. However, it may be preferable to allow for the effect of extensive changes in deadwood by recalibration of the tank.

Table 1 - Variation in tank capacity (%) with change in diameter

Normal tank diameter in metres	Approximate variation in capacity (%)					
	0,01	0,02	0,03	0,04	0,05	0,06
	Produced by (mm) change in tank diameter					
5	-	-	1	1	1	1
10	-	1	1	2	2	3
15	(1)	1	2	3	4	4
20	(1)	2	3	4	5	6
25	(1)	2	4	5	6	7
30	(1)	3	4	6	7	9
35	(2)	3	5	7	9	10
40	(2)	4	6	8	10	12
45	(2)	4	7	9	11	13
50	(2)	5	7	10	12	15
55	(3)	5	8	11	14	16
60	(3)	6	9	12	15	18
65	(3)	6	10	13	16	19
70	(3)	7	10	14	17	21
75	(4)	7	11	15	19	22
80	(4)	8	12	16	20	24
85	(4)	8	13	17	21	25
90	(4)	9	13	18	22	27
95	(5)	9	14	19	24	28
100	(5)	10	15	20	25	30
105	(5)	10	16	21	26	31
110	(5)	11	16	22	27	33
115	(6)	11	17	23	29	34
120	(6)	12	18	24	30	36
NOTE - Figures in parentheses are within the measurement tolerance for reference strapping (see ISO 7507-1). Caution should be exercised in using such data as indicators of the need for recalibration.						

Table 2 - Variation in capacity (%) due to alteration in thickness of bottom course plate of tank

Normal tank diameter in metres	Variation in capacity (%) of bottom course (nominal plate height, 2 m) for reductions in plate thickness of 1,5 mm to 3 mm			
	1,5 mm	**2,0 mm**	**2,5 mm**	**3,0 mm**
10	0,38	0,05	0,63	0,76
15	0,25	0,34	0,42	0,50
20	0,19	0,25	0,31	0,38
25	0,15	0,20	0,25	0,30
30	0,13	0,17	0,21	0,25
35	0,11	0,14	0,18	0,22
40	0,09	0,13	0,16	0,19
45	0,08	0,11	0,14	0,17
50	0,08	0,10	0,13	0,15
55	0,07	0,09	0,11	0,14
60	0,06	0,08	0,10	0,13
65	0,06	0,08	0,10	0,12
70	0,05	0,07	0,09	0,11
75	0,05	0,07	0,08	0,10
80	0,05	0,06	0,08	0,09
85	0,04	0,06	0,07	0,09
90	0,04	0,06	0,07	0,08
95	0,04	0,05	0,07	0,08
100	0,04	0,05	0,06	0,08
105	0,04	0,05	0,06	0,07
110	0,03	0,05	0,06	0,07
115	0,03	0,04	0,05	0,07
120	0,03	0,04	0,05	0,06
NOTE - Plate thickness should be measured at 8 points circumferentially on the bottom courses and averaged.				

Table 3 - Capacity correction for tank tilt

Tilt (millimetre per metre)	Capacity correction factor (%)
14	0,010
16	0,013
18	0,016
20	0,020
22	0,024
24	0,029
26	0,034
28	0,039
30	0,045

Table 4 - Effect on tank capacity variations in shell, ambient air and liquid temperatures

Variation in shell temperature, T_S °C	Variation in ambient air temperature, T_A °C	Variations in liquid temperature, T_L °C	Approximate variation in capacity %
5	10	10	0,01
10	20	20	0,03
15	30	30	0,04
20	45	45	0,05

Table 5 - Effect on tank capacity of change in liquid density

Variation in density (%)	**Approximate variations in capacity** (%)
10	0,008 to 0,015
20	0,015 to 0,030
30	0,030 to 0,040
40	0,040 to 0,050
50	0,050 to 0,065
NOTE - Variations in hydrostatic head corrections are dependent on plate thickness and liquid column heights as well as variations in density. Actual variations in capacity may differ significantly from the figures in the above table, if plate thickness or liquid column heights differ significantly from the industry's accepted practice.	

Annex A
(normative)

Tank shell temperature determination

A.1 General

Criteria are given in 7.2 and table 4 indicating a requirement to recalculate a tank calibration table if the average operating temperature of the tank shell alters from the original reference temperature printed on the tank capacity table.

Determination of the average operating temperature shell may be based on either:

a) a temperature assumed to be the average operating temperature of the tank shell;
or

b) by several actual measurements of the parameters detailed in A.2 which determine that temperature and calculating an average of the temperatures.

A.2 Determination of the tank shell temperature

Determination of the tank shell temperature may be calculated using the following equation:

$$T_S = \frac{T_L + (K \times T_A)}{K + 1}$$

where

T_S is shell temperature, in degrees Celsius;

T_L is liquid temperature, in degrees Celsius, for $T_L < 66$;

T_A is ambient temperature, in degrees Celsius;

K $= \{(T_L x\ 7,2) + (324 \text{ x } V \text{ x } \mu^{0,5}) + (3\,121 \text{ x } \mu^{0,32}) - (222 + D \text{ x } 3,05)\} \text{ x } 10^{-4}$

μ is viscosity, in pascal seconds, for $10^{-3} < \mu < 1$;

D is tank diameter, in metres, for $15 < D < 85$;

V is wind velocity, in kilometres per hour, for $0 < V < 19$.

A.3 Simplified equation for tank shell temperature

In practice the determination of viscosity, wind velocity and tank shell temperature may prove difficult. However, the equation in A.2 involving these parameters may be simplified using the following equation:

$$T_S = \frac{(7 \times T_L) + T_A}{8}$$

Annex B
(informative)

Bibliography

[1] SIVARAMAN, S and HAMPSON, B.J., Guidelines set for recalibration of storage tanks, *Oil and Gas Journal*, 12 June 1989.

The following list of ISO standards contain information which may prove of use to the reader of this part of ISO 7507.

[2] ISO 7507-2:1993, Petroleum and liquid petroleum products - Calibration of vertical cylindrical tanks - Part 2: Optical-reference-line method.

[3] ISO 7507-3:1993, Petroleum and liquid petroleum products - Calibration of vertical cylindrical tanks - Part 3: Optical-triangulation method.

[4] ISO 7507-4:1995, Petroleum and liquid petroleum products - Calibration of vertical cylindrical tanks - Part 4: Internal electro-optical distance-ranging method.

[5] ISO 7507-5:—[1)], Petroleum and liquid petroleum products - Calibration of vertical cylindrical tanks - Part 5: External electro-optical distance-ranging method.

1) To be published.

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