



Engineering Procedure

SAEP-22

4 April 2006

Tank Calibration Requirements

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Saudi Aramco DeskTop Standards

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1 Scope

This procedure establishes the instructions and responsibilities for the calibration of above-ground upright cylindrical tanks, horizontal tanks, spheres and spheroids used for all Saudi Aramco royalty/custody tank gauging and/or storage inventory measurement systems.

Organizations for which responsibilities are specified include, but are not limited to:

- The Proponent Organization
- Saudi Aramco Project Management Team (SAPMT)
- Process & Control Systems Department (P&CSD)

2 Conflicts and Deviations

- 2.1 Any conflicts between this procedure and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this procedure in writing in accordance with [SAEP-302](#) to the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.
- 2.3 Direct all requests for interpretation of this procedure in writing to the chairman, Custody Measurement Standards Committee for resolution. The Chairman, Custody Measurement Standards Committee shall be solely responsible for determining whether a proposed request meets the requirements of this standard.

3 Applicable Documents

The procedures covered by this document shall comply with the latest edition of the references listed below, unless otherwise noted:

- 3.1 Saudi Aramco Engineering Procedure
[SAEP-302](#) *Instructions for Obtaining a Waiver of a
Mandatory Saudi Aramco Engineering
Requirement*
 - 3.2 American Petroleum Institute (API) Manual of Petroleum Measurement
Standards (MPMS)
*Chapter 2.2A Measurement and Calibration of Upright
Cylindrical Tanks by the Manual Strapping*
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	<i>Method</i>
<i>Chapter 2.2B</i>	<i>Calibration of Upright Cylindrical Tanks Using the Optical-Reference Line Method</i>
<i>Chapter 2.2C</i>	<i>Calibration of Upright Cylindrical Tanks Using the Optical-Triangulation Method</i>
<i>Chapter 2.2D</i>	<i>Calibration of Upright Cylindrical Tanks Using the Internal Electro-optical Distance Ranging Method</i>
<i>Chapter 2.2E</i>	<i>Calibration of Horizontal Cylindrical Tanks-Part 1: Manual Methods</i>
<i>Chapter 2.2F</i>	<i>Calibration of Horizontal Cylindrical Tanks-Part 2: Internal Electro-Optical Distance-Ranging Method</i>
<i>Standard 2552</i>	<i>Method for Measurement and Calibration of Spheres and Spheroids</i>
<i>Standard 2555</i>	<i>Liquid Calibration of Tanks</i>

4 Definitions and Acronyms

4.1 Definitions

Approve: Review and formal acceptance characterized by the signature of the final authorizing individual or organization.

Capacity Table: A table often referred to as a tank capacity table or calibration table, showing the capacities of or volumes in a tank for various liquid levels measured from the reference gauge point.

Critical Zone: The region between initial and complete flotation of a floating roof.

Custody Transfer Measurement: A specialized form of measurement that provides quantity and quality information used for the physical and fiscal documentation of a change in ownership and/or responsibility of commodities. The following measurements are custody transfer measurements:

- Measurement of hydrocarbon liquid or gas movements (deliveries or receipts) between Saudi Aramco and its Customers, suppliers, or transport contractors.
- Measurement of hydrocarbon liquid or gas transfers within, or between, Saudi Aramco business entities (e.g., refineries, bulk plants, terminals,

VELA, etc.) where the measurement is used for accounting or loss control.

Customer: The party that takes ownership or responsibility of a hydrocarbon commodity from Saudi Aramco.

Deadwood: Deadwood refers to any object within the tank, including a floating roof, which displaces liquid and reduces the capacity of the tank; also any permanent appurtenances on the outside of the tank, such as cleanout boxes or manholes, which increase the capacity of the tank.

External Floating Roof: A cover over an open top storage tank consisting of a deck which rests upon the liquid being contained.

Internal Floating Roof: A cover within a fixed roof tank which rests upon the petroleum liquid being contained.

Master Tape: A tape that is used for calibrating working tapes for tank measurements and is identified with a report of calibration at 68°F (20°C) and a specific tension designated by the National Institute of Standards and Technology (NIST) or an equivalent international standard organization.

Recomputation: The process of re-generating the capacity tables through soft calculations, without repeating the field calibration measurements. It involves, simply, updating or revising the capacity table using previously established tank diameters

Reference Gauge Height: The distance from the datum plate or tank bottom to the reference gauge point.

Royalty Measurement: A specialized form of measurement that is used as the basis for paying royalty to the Saudi Arabian Government.

Spheres: A stationary liquid storage tank, supported on columns so that the entire tank shall be aboveground.

Spheroid: A stationary liquid storage tank having a shell of double curvature. Any horizontal cross-section is a series of circular arcs.

Strapping: The measurement of the external circumference of a vertical or horizontal cylindrical tank by stretching a steel tape around each course of the tank's plates and recording the measurement.

Tank Calibration: The process of determining the capacity of a tank through field measurements.

Third Party Inspection Agency: An independent inspection agency whose function is to conduct an unbiased inspection of certain systems, equipment, materials, etc., against a set of standards, guidelines or procedures. For purposes of this SAEP, the Third Party Inspector has particular knowledge of and experience of conducting tank calibration in accordance with industry custody measurement standards and procedures.

4.2 Abbreviations

API	American Petroleum Institute
CMU	Custody Measurement Unit of Process & Control Systems Department
EODR	Electro Optical Distance Ranging
ORLM	Optical Reference Line Method
MINPET	Ministry of Petroleum and Mineral Resources
MPMS	Manual of Petroleum Measurement Standards
P&CSD	Process & Control Systems Department
PID	Process Instrumentation Division
SA	Saudi Aramco
SAEP	Saudi Aramco Engineering Procedure
SAES	Saudi Aramco Engineering Standard
SAMSS	Saudi Aramco Material Specification
SASD	Saudi Aramco Engineering Standard Drawing

5 Instructions

51. General

This guideline shall be used in conjunction with existing international standards and is not intended to replace the standards referred to in Section 3 above.

5.2 Calibration/Re-calibration Frequencies

All new tanks/vessels must undergo calibration prior to being put in service.

All tanks/vessels must be recalibrated in conjunction with Testing and Inspection (T&I).

The upright cylindrical tank shall be recalibrated in accordance with API MPMS Chapter 2.2A, Appendix A. Use a criteria of +0.02% change in volume detected.

5.3 Precalibration Preparations

Prior to calibration, the upright cylindrical tanks, horizontal tanks, spheres and spheroids must have been filled to 95% of their design operating capacity for a minimum period of 24 hours with a liquid at least as dense as the product they will normally store.

Commentary Note:

This requirement is considered met if the tank/vessel has been already hydro-tested.

5.4 Recomputation Requirements

The capacity table of horizontal tanks, spheres and spheroids must be recomputed if variation in product operating temperatures and temperature assumed during calibration is greater than 20°F.

Commentary Note:

Variations in the product's calibration specific gravity and operating specific gravity greater than 20% will require a recomputation of the table, due to the hydrostatic head effect expansion on tanks/vessels.

Floating roof correction table requires recomputation when any variation in the roof's weight, due to repairs or modifications, results in a change in the roof deadweight of more than +0.02%.

Commentary Note:

While recalibration involves reestablishing tank diameters through standard calibration methods and developing new tank capacity tables for custody and non-custody transfers, recomputation, involves simply updating or revising the capacity table using previously established tank diameters.

5.5 Acceptable Calibration Technologies

Following is a list of the calibration technologies acceptable for tank/vessel calibrations along with the reference standard the methods' implementation should comply to. The methods are arranged in the order of priority, based on the most efficient means of calibration for a given set of conditions.

- (1) Internal Electro Optical Distance Ranging Method (EODR),
API Chapter 2.2D
- (2) Internal Electro-Optical Distance-Ranging Method (EDOR),
API Chapter 2.2F
- (3) Optical Reference Line Method (ORLM), API Chapter 2.2B

- (4) Manual Strapping Method (Strapping), API Chapter 2.2A
- (5) Optical-Triangulation Method, API Chapter 2.2C
- (6) Manual Methods, API Chapter 2.2E
- (7) Liquid Calibration, API 2555
- (8) Method for Measurement and Calibration of Spheres and Spheroids, API STD 2552

Commentary Note:

All these methods essentially provide alternate techniques for measuring tank diameters. While manual strapping is limited to external calibrations, the remaining methods can be used either externally or internally.

5.6 Technology Selection Guidelines

- a. The application of the EODR shall be limited to tanks/vessels that are greater than 5 meters in diameter.
- b. The application of liquid calibration shall be limited to tanks/vessels that are smaller than 5 meters in diameter.
- c. If a tank/vessel is insulated, it should be calibrated internally.
- d. External and internal EODR shall be used for all tanks/vessels that are greater than 5 meters in diameter with no insulation.
- e. Either Internal or external ORLM shall be used for floating roof tanks.
- f. External ORLM can be used for fixed roof tanks with no insulation and having not more than a single wind girder.
- g. If the tank has multiple external wind girders, it should be calibrated either by external/internal EODR or internal ORLM.
- h. Tank bottom shall be calibrated by a physical survey. In a physical survey, bottom elevations shall be sighted along radii every 45 degrees. Along these radii, elevations should be obtained at equally spaced intervals not more than 10 feet (3 meters) from the tank's center to its shell. Liquid calibration method is permitted to be used of whenever the tank contains irregular shaped deadwood (e.g., steam coils, etc.).
- i. Spheres and spheroids shall be calibrated in accordance with API STD 2552, Method for Measurement and Calibration of Spheres and Spheroids.

6 Responsibilities

The Saudi Aramco organizations with tank/vessels calibration responsibilities shall ensure that their personnel become familiar with this SAEP.

6.1 Saudi Aramco Project Management Team (SAPMT)

- a. Initiate calibration request for new tanks/vessels,
- b. Inform CMU of the calibration,
- c. Request list of Approved Third Party Inspection Agencies,
- d. Contract tank calibrations to an approved Third Party Inspection Agencies,
- e. Inform the Proponent to witness the calibration process,
- f. Obtain the capacity tables from the Proponent,
- g. Request CMU's approval for capacity tables,
- h. Provide two hardcopy and two electronic tables in US Customary units and metric units of the final approved calibration calculation and the capacity table,
- i. Close the activity.

6.2 The Proponent Organization

- a. Initiate requests for in-service tanks/vessels per the frequency requirements set fourth in Section 4 above,
 - b. Inform CMU of the calibration,
 - c. Request list of the approved Third Party Inspection Agencies,
 - d. Contract tank calibrations to an approved Third Party Inspection Agency,
 - e. Provide the operating data (operating temperature, density at operating temperature, operating pressure) to the Third Party Inspection Agency,
 - f. Ensure the equipment used has been calibrated within the previous year and that such calibrations are traceable to National Institute of Standard and Technology (NIST) or other approved standards organization,
 - g. Witness the field calibration process and ensure that the Third Party Inspection Agency is performing the tank/vessel calibration calculations in accordance API MPMS Chapter 2.2A and API STD 2552, including, but not limited to, the following capacity table correction factors,
 - i. master tape corrections.
 - ii. working tape correction.
 - iii. tape rise correction.
 - iv. tank shell temperature expansion correction.
 - v. hydrostatic head effect correction.
 - vi. tilt correction.
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- vii. floating roof gravity adjustment.
- h. Consult with CMU if a technical inquiry about the calibration and/or documentation process cannot be resolved in-house,
- i. Review the draft calibration calculations,
- j. Review the produced capacity tables and make sure they comply with the requirements at Attachment 1,
- k. Submit the capacity tables for the calibration of the new tanks to the SAPMT,
- l. Submit capacity tables to CMU for approval for and in cases where a capacity table of an existing tank raises technical reservations that could not be resolved by the proponent,
- m. Provide two hardcopy and two electronic tables in US Customary units and metric units of the final approved calibration calculation and the capacity table,
- n. Update the SAP tank Gauging system with the new approved capacity table,
- o. Informing the SAPMT of the completion of the tank calibration,
- p. Commission the tank,
- q. Close the activity.

6.3 Process & Control Systems Department (P&CSD)

The Process & Control Systems Department/Custody Measurement Unit (CMU) is responsible for providing technical assistance to the Proponent(s) on matters pertaining to tank calibrations. Specific responsibilities of CMU are summarized below:

- a. Review the qualifications of the Third Party Inspection Agencies and make sure they meet all of the requirements detailed in Attachment II.
 - b. Maintain the list of Approved Third Party Inspection Agencies.
 - c. Inform MINPET of the calibration of a royalty storage tank.
 - d. Submit the list of the Approved Third Party Inspection Agencies to the SAPMT and the proponent upon request.
 - e. Upon request from the proponent, provide consultation if a technical inquiry about the calibration and/or documentation process cannot be resolved in-house.
 - f. Upon request from proponent, review tank/vessel calibration draft calculation and make sure they comply to the requirements detailed in
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Attachment 1.

- g. Upon request from proponent, review tank/vessel capacity tables and make sure they comply to the requirements detailed in Attachment 1.
- h. In case of calibrating royalty storage tanks, obtain the approval of the capacity tables from Ministry of Petroleum & Mineral Resources (MINPET).
- i. Informing the SAPMT of the completion of the tank calibration.
- j. Ensure that the SAP tank gauging system is updated with the new approved capacity tables.

7 Activity Matrix

The following matrix summarizes the general sequence of activities and corresponding responsible organizations for calibrating tanks. Detailed requirements for each organization are specified in Section 6.

Step	Activity/Work Item	Perform	Review	Approve
1	Review the qualifications of the Third Party Inspection Agencies and make sure they meet all of the requirements detailed in Attachment II.	CMU		
2	Maintaining the list of Approved Third Party Inspection Agencies	CMU		
3	Initiating request for tank/vessel calibration	SAPMT/Proponent ⁽¹⁾		
4	Informing CMU of the calibration	SAPMT/Proponent		
5	Informing MINPET of the calibration ⁽²⁾	CMU		MINPET ⁽²⁾
6	Requesting list of Approved Third Party Inspection Agencies	SAPMT/Proponent		
7	Submitting list of Approved Third Party Inspection Agencies to SAPMT and Proponent upon request	CMU		
8	Contracting tank calibrations to an approved Third Party Inspection agency	SAPMT/Proponent		
9	Selecting the Method of Calibration	Third Party Inspection Agency		
10	Informing the Proponent to witness the calibration process	SAPMT		
11	Providing the operating data to the Third Party Inspection Agency	Proponent		
12	Ensuring the equipment used has been calibrated traceable to National Institute of Standard and Technology (NIST) or other approved standards organizations	Proponent		
13	Conducting the calibration in accordance to section 4	Third Party Inspection Agency		
14	Performing tank/vessel calibration calculations	Third Party Inspection Agency		

Step	Activity/Work Item	Perform	Review	Approve
15	Witness the field calibration process.	Proponent		
16	Consulting with CMU if a technical inquiry about the calibration and/or documentation process cannot be resolved in-house.	Proponent		
17	Reviewing the draft calibration calculations	Proponent	CMU	
18	If requested, reviewing the draft calibration calculations.	CMU		CMU
19	Reviewing the tank capacity tables	Proponent		
20	Submit the capacity tables for the calibration of the new tanks to the SAPMT	Proponent		
21	Submitting the tank capacity table	SAPMT/Proponent		
22	Approval of the new capacity table	CMU		
23	Providing two hardcopy and two electronic tables in US Customary units and metric units of the final approved calibration calculation and the capacity table	SAPMT/Proponent		CMU
24	Obtaining MINPET approval for the tank Capacity Table	CMU		MINPET ⁽²⁾
25	Informing the Proponent and SAPMT of the final approval of the capacity Table	CMU		
26	Updating SAP Tank Gauging System with the new approved capacity table	Proponent		
27	Informing the SAPMT of the completion of the tank calibration	Proponent		
28	Commissioning the tank	Proponent		
29	Closing the activity	SAPMT/Proponent		

Notes:

1. SAPMT initiates calibration request for new tanks/vessels. The Proponent initiates calibration Request for tanks/vessels in-service per the frequency requirements set fourth in Section 4 above. For BI-1900, the proponent will assume the responsibilities of SAPMT.
2. MINPET involvement is only required for calibration of royalty transfer storage tanks.

Revision Summary

4 April 2006

New Saudi Aramco Engineering Procedure.

Attachment I

Required Information on the Tank Capacity Table

The final capacity table should contain the following minimum documentation details.

1. Tank identification
 - a. The site or installation tank number
 - b. The type of tank in service
 - c. The name of the owner or operator
 - d. The name and address of the calibration authority or company which carried out the calibration.
 2. Product information

The product name and density of the liquid stored in the tank when in service and used in the computation of the tank capacity tables.
 3. Operational details
 - a. The standard temperature (60°F for U.S. Customary, or 15°C for metric tables) for which the tank capacity table has been calculated.
 - b. Operating temperature and pressure
 4. Traceability and tracking details
 - a. The date a new tank was first calibrated
 - b. The date an old tank was recalibrated
 - c. Method of Calibration
 - d. The date the tank was recomputed, and the method used for recomputation
 - e. The date of the calibration along with specific references to the method adopted in calibrating the tank bottom
 - f. The date of issue of the certificate
 - g. Reference to the standard on which the calibration is based
 - h. The Third Party Inspection Agency shall sign each page of the certificate.
 5. Tank dimensions
 - a. The nominal height and diameter of the tank
 - b. Description of the tank bottom type, along with the method used to determine the bottom volume
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- c. Integrated deadwood, accurately accounted for as to location and volume, and included as an attachment
 - d. Note on capacity table that the volume below the striking plate is included in the first measurement
 - e. The shell height, is measured as the vertical distance between the bottom of the bottom angle and top of the top angle and measured near the reference gauge hatch
 - f. Reference height measurement point locations shall be clearly identified on tank capacity tables
 - g. The height of the datum-points(s) with reference to the junction of the tank shell and bottom plating
 - h. If an automatic gauging system is installed, the height of the gauge datum point with reference to the junction of the tank shell and bottom plating
 - i. Maximum fill height
 - j. Safe fill height specified by the tank owner
 - k. The amount of tilt in shell height is measured and recorded.
 - 6. Floating roof information
 - a. The allowance for the roof is to be treated as deadwood and incorporated in the tank capacity table directly, not as a separate attachment
 - b. The density of the liquid for which the roof has been calculated shall be recorded on the table directly
 - c. The apparent mass in air of the roof and accessories
 - d. The displacement volume of the roof
 - e. A defined level (Level A), with the distance above the dip point designating where the roof is at rest
 - f. A defined level (Level B), with the distance when the roof is just fully floating in the lowest-density liquid to be contained in the tank
 - g. The part of the capacity table between Level A and Level B is marked as "Not Accurate".
 - 7. Tank shell correction
 - a. A shell temperature expansion factor table is to be developed in increments of 5°F or 3°C and included as an attachment to the capacity table for a specific operating range.
 - b. Include the equation for determining the shell temperature.
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Attachment II

Qualifications of the Third Party Inspection Agency

The Third Party Inspection Agency shall meet all of the following requirements:

1. The agency has provided similar services for a minimum of 3 years. It shall submit a list of companies for which it has provided similar calibration services over the preceding 3 years.
2. The agency's personnel performing the field measurements and calculations must have a minimum of one year experience with the application of the API tank/vessel calibration standards. Experience shall be documented by submittal of resume and verifiable work histories.
3. The agency shall have written procedures which meet the requirements of API tank/vessel calibration standards. It shall submit the written procedures for review.
4. The agency shall have equipment as specified in API MPMS Chapter 2.2. It shall submit a list of the equipment it intends to use along with corresponding valid calibration certificates.
5. The agency shall demonstrate it is ISO-certified and that it is actively administering a quality assurance program. It shall submit a copy of its ISO certification and his quality assurance program details for review.
6. The agency shall demonstrate that it is capable of performing the tank/vessel calibration calculations. It shall provide a minimum of two samples of previous calibration results, including field data and all calculations.
7. The agency shall provide financial and insurance documentations as deemed necessary by the Contracting Unit to ensure he has adequate liability coverage for damages done to Saudi Aramco facilities.