



Engineering Standard

SAES-Y-301

29 September 2013

Royalty/Custody Measurement of Hydrocarbon
Liquids using Radar Tank Gauging Systems

Document Responsibility: Custody Measurement Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This standard describes the minimum mandatory requirements governing the design, construction and installation of Radar Tank Gauging (RTG) systems and equipment for royalty/custody transfer measurement of hydrocarbon liquids.

This standard is restricted to stilling well mounted RTG systems in atmospheric upright cylindrical, above ground, liquid storage tanks.

This standard excludes RTG systems for LPG service and asphalt transfers, transfers from or to ships, truck loading and truck unloading. RTG usage for transfers from or to ships shall be approved by the Chairman, Custody Measurement Standards Committee.

2 Conflicts and Deviations

- 2.1 Any conflicts between this standard 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 standard in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.
- 2.3 Direct all requests for interpretation of this standard in writing to the Company or Buyer Representative, who shall forward them 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 References

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

3.1 Saudi Aramco Documents

Saudi Aramco Engineering Procedures

[SAEP-22](#)

Tank Calibration Requirements

[SAEP-28](#)

*Royalty/Custody Radar Tank Gauging Equipment
Verification Requirements*

[SAEP-302](#) *Instructions for Obtaining a Waiver of a
Mandatory Saudi Aramco Engineering
Requirement*

Saudi Aramco Engineering Standards

[SAES-D-100](#) *Design Criteria of Atmospheric and Low Pressure
Tanks*

[SAES-J-003](#) *Instrument Basic Design Criteria*

[SAES-J-004](#) *Instrument Symbols and Identification*

[SAES-J-005](#) *Instrument Drawings and Forms*

[SAES-J-200](#) *Pressure*

[SAES-J-400](#) *Temperature*

[SAES-J-902](#) *Electrical Systems for Instrumentation*

[SAES-J-903](#) *Intrinsically Safe Systems*

[SAES-P-103](#) *UPS and DC Systems*

[SAES-P-104](#) *Wiring Methods and Materials*

[SAES-P-111](#) *Grounding*

[SAES-Y-100](#) *Regulated Vendor List for Custody Measurement
Equipment*

[SAES-Y-103](#) *Custody/Royalty Metering of Hydrocarbon
Liquids*

Saudi Aramco Materials System Specification

[34-SAMSS-321](#) *Radar Tank Gauging System for Royalty/ Custody
Measurement of Hydrocarbon Liquids*

Saudi Aramco Standard Drawing

[AA-036256](#) *General Assembly of Radar, Temperature and
Manual Tank Gauging for External Floating
Roof Tanks*

Saudi Aramco Library Drawing

[DC-950043](#) *Electrical Connections for Field-Mounted
Instruments*

3.2 Industry Codes and Standards

American Petroleum Institute (API) Manual of Petroleum Measurement Standards (MPMS)

<i>Chapter 3, Section 1B</i>	<i>Standard Practice for Level Measurement of Liquid Hydrocarbons in Stationary Tanks by Automatic Tank Gauging</i>
<i>Chapter 3, Section 6</i>	<i>Measurement of Liquid Hydrocarbons by Hybrid Tank Measurement Systems</i>
<i>Chapter 7</i>	<i>Temperature Determination</i>
<i>Chapter 8, Section 1</i>	<i>Standard Practice for Manual Sampling of Petroleum and Petroleum Products</i>
<i>Chapter 12, Section 1</i>	<i>Calculation of Static Petroleum Quantities – Upright Cylindrical Tanks and Marine Vessels</i>

4 Definitions and Abbreviations

4.1 Definitions

Automatic tank gauge (ATG): An instrument intended to measure automatically and display the level of the liquid contained in a tank with respect to a fixed reference. An automatic tank gauge includes at least a liquid level-detecting element, a transducer, if applicable, and an indicating device.

Automatic Tank Thermometers (ATTs): Instruments that continuously measure temperature in storage tanks. ATT (also known as an automatic tank temperature system) typically includes precision temperature sensors, field mounted transmitters for electronic signal transmission, and receiving/readout device(s).

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

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 hydrocarbon commodities. This includes measurement of hydrocarbon liquid movements (deliveries or receipts) between Saudi Aramco and its customers, suppliers, joint ventures and transport contractors including VELA ships.

Datum plate (Dip plate): A level metal plate located directly under the reference gauge point to provide a fixed contact surface from which liquid depth measurement can be made.

External Floating Roof: A cover over an open top storage tank consisting of a deck which freely rests upon the liquid being contained except at low levels when the weight of the cover is transmitted by its supporting legs to the tank bottom.

Initial Setting of RTG System: The initial setting of the RTG System is the process by which the RTG level reading is set equal to the average tank liquid level; determined by the manual reference level measurement (at a single level). The initial setting also includes verification of the ATT sensors.

Radar Tank Gauging (RTG) System: RTG is defined in this document as the total of the electronic measuring systems consisting of a radar-based Automatic Tank Gauge (ATG) and Automatic Tank Thermometers (ATT).

Rated operating conditions: The conditions of use, giving the range of values of influence quantities for which the metrological characteristics are intended to lie within the specified permissible errors.

Reference gauging point: A point clearly marked on the principal gauge hatch located along the vertical axis ascending from the dip-ping datum point to indicate the reference position to which ullage is measured.

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

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

Test Difference: The indication of an RTG minus a true value of the corresponding input quantity.

4.2 Abbreviations

API	American Petroleum Institute
ATG	Automatic Tank Gauging
ATT	Automatic Tank Thermometer
CMU	Custody Measurement Unit of Process & Control Systems Department
MPMS	Manual of Petroleum Measurement Standards
RTG	Radar Tank Gauge

SAEP	Saudi Aramco Engineering Procedure
SAES	Saudi Aramco Engineering Standard
SAMSS	Saudi Aramco Material System Specification
SAPMT	Saudi Aramco Project Management Team
SASD	Saudi Aramco Standard Drawing

5 General Requirements

- 5.1 This Standard is not intended to be an exclusive listing of RTG instrumentation. Refer to [34-SAMSS-321](#) for equipment requirements.
- 5.2 Tank measurement is not a preferred method compared to metering. However, RTG may be considered the optimum choice at some locations providing an economic analysis is performed to justify that it is more cost effective than dynamic measurements. If the economics for an RTG system cannot be justified, then a metering system shall be installed as per [SAES-Y-103](#).
- 5.3 Only RTG systems are approved to perform automatic tank level gauging and temperature measurement.
- 5.4 RTG systems shall be supplied by Saudi Aramco approved vendors in accordance with [SAES-Y-100](#).
- 5.5 SAPMT is responsible for ensuring the design and construction contractors provide a fully operational RTG system that meets both the provisions of this standard and the approved project functional specifications.

6 Equipment Requirements

- 6.1 Radar Tank Gauge Requirements
 - 6.1.1 The RTG shall be installed in accordance with the manufacturer's recommendations and [SAES-P-111](#).
 - 6.1.2 RTG system and its accessories shall meet the requirements of API MPMS 3.1B, [SAES-J-003](#) and [34-SAMSS-321](#) in terms of accuracy, installation, factory calibration, initial and subsequent verifications.
 - 6.1.3 RTG should be capable of withstanding the operating and environmental conditions encountered in service. All exposed metal parts shall have the same electrical potential as the tank.
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- 6.1.4 RTG should be mounted on a properly supported, perforated stilling well. Roof mounted RTG systems are not accepted for custody transfer.
- 6.1.5 RTG shall provide security sealing to prevent unauthorized tampering or adjustment.
- 6.2 Automatic Tank Thermometer (ATT) Requirements
 - 6.2.1 The ATT shall conform to the requirements specified in [SAES-J-400](#) and [34-SAMSS-321](#).
 - 6.2.2 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.
 - 6.2.3 ATT shall be installed so that they are 900 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. The ATT shall be installed as to be accessible from gauge platform.
 - 6.2.4 For fixed-roof and floating-roof tanks a form of averaging temperature measurement will give greater accuracy and is preferred.
- 6.3 Pressure Sensors

Pressure sensors may be added in accordance with API MPMS Chapter 3.6 for determinations of tank density for operational purposes. The density values obtained shall not be used for custody transfer measurement. Pressure Instrumentations shall comply with [SAES-J-200](#).

7 Process Requirements

The following process conditions and operational activities affect the accuracy of level and temperature measurements. They shall be observed in applicable circumstances.

7.1 Weather

Calibration shall not be performed during high winds or severe storms, both for safety and to avoid movement of the tank shell, the RTG, or the liquid surface.

7.2 Ambient Temperature

Due to the effect of the ambient condition on the thermal expansion of the tank shell and supporting pipe, ambient temperature shall be measured and shell

correction factor shall be considered. Ambient temperature measuring device shall be installed at the tank farm area externally at shaded area that is away by more than one meter from any obstruction. This ambient temperature measuring device shall have accuracy of 1°C or better and verified every three months.

7.3 Initial Filling

Before the initial calibration is performed, the tank shall have been filled once, to minimize the errors caused by initial bottom settlement.

7.4 Settling Time

The tank shall be allowed to stand at a constant level for the tank to reach a stable position. If a tank mixer is present, it shall be turned off to allow the liquid to come to rest. This settling time can be shortened if the tank is at a constant level and air or vapor being released from the liquid and the tank bottom has stabilized. The tank inlet and outlet shall be kept closed during this time.

7.5 The range of relative density changes in the tank shall not be such as to affect the vertical temperature distribution measured by the ATT elements.

8 Tank Requirements

8.1 General Requirements

8.1.1 Tanks shall be constructed to meet the requirements of [SAES-D-100](#), Design Criteria of Atmospheric and Low Pressure Tanks, and Standard Drawing [AA-036256](#), General Assembly of Radar, Temperature and Manual Tank Gauging for External Floating Roof Tanks. Other applicable requirements per API MPMS 3.1B shall be met.

Commentary Note:

The accuracy of an RTG installation is directly dependent upon the condition of the tank on which it is installed. Old and/or incorrectly erected tanks, particularly those with unstable bottoms, shell or roofs, will introduce additional error.

8.1.2 Tanks shall be constructed to allow easy accessibility to the gauging hatch and provide sufficient area to perform gauging and verification activities. A minimum of one level gauging instrument per tank, readable from grade shall be specified. A minimum of one gauging port shall be installed adjacent to the gauging platform and located away from regions of turbulent flow.

- 8.1.3 Each manual gauge hatch shall have a permanent gauge mark or tab just inside the cap on the gauge hatch wall called a “reference point” or “knife edge” to exactly define the location of the tape during dipping.
 - 8.1.4 Remote Readout shall be installed at the tank dike close to the tank stairs with resolution equal to 1 mm (1/16 inch) or better. Provisions for signal security, transient and surge protection shall meet API MPMS Chapter 3.1B.
 - 8.1.5 Tanks shall have valid capacity tables. If the capacity table is not valid, the tank shall be calibrated by an approved independent calibration agency in accordance with [SAEP-22](#), Tank Calibration Requirements.
 - 8.1.6 The tank’s inlet and outlet valves shall be double block & bleed to prevent any leak may impact the measurement of the liquid measured.
 - 8.1.7 The thermal expansion of the tank shell or, if applicable, the support pipe, shall be such that the total deviation for temperature changes will fall within the accuracy requirements for the installed RTG gauge, or if necessary be compensated for. If temperature sensing elements are used to apply corrections to the indication they shall be mounted in such a way that a correct average temperature is obtained.
 - 8.1.8 Calculations for floating roof adjustments and shell temperature corrections shall be calculated per API MPMS Chapter 12.1.
 - 8.1.9 All valves associated with isolation of the tank during custody measurement shall have double block-and-bleed functionality to verify the tanks are sealing the liquid.
- 8.2 Requirements for Datum Plates
- 8.2.1 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 gage hatch at a fixed distance from the bottom, preferably not less than 5 cm.
Commentary Note:
Since the datum plate provides a zero reference for innage gauge measurements, movement of the datum plate will cause innage gauge measurements errors.
 - 8.2.2 The center line of the datum plate shall be 900 mm from the tank shell in order to minimize temperature effects from the tank shell.
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8.3 Requirements for Stilling Wells

8.3.1 General Requirements

- 8.3.1.1 A manual gauging and sampling stilling well shall be dedicated per API MPMS Chapter 8.1. RTG systems requiring insertion of a secondary stilling well inside the original stilling well will not be accepted if the stilling well is used for manual sampling.
 - 8.3.1.2 It is essential that the mounting locations have minimum vertical movement with respect to the tank reference, which is the joint where the tank shell and bottom meet, or the bottom of the corner. For this reason, only stilling well mounted systems shall be considered.
 - 8.3.1.3 The minimum diameter of the stilling well should be 8 inches. The stilling well shall be the same diameter throughout its length, as changes in pipe diameter change the speed of radar affect the absolute accuracy of the system. Smaller size pipes are acceptable if they provide sufficient structural strength to support RTG installations; and the stilling well is wide enough to allow the operator to collect manual samples.
 - 8.3.1.4 A stilling well shall be supported at the lowest part of the tank shell less than 1 foot from the tank bottom in accordance with the requirements of API MPMS Chapter 3.1B. The lower end of the stilling well should extend to within 12" of the tank bottom.
 - 8.3.1.5 The top end of the stilling well should be properly guided per API 3.1B to allow for vertical movement of the tank shell and tank roof.
 - 8.3.1.6 All tank stilling wells shall be grounded to the tank. It is advised to have at least two braided wires between the tank shell and stilling well, preferably one at the bottom and one on the tank roof. The braided wires should be at least 2" x 0.25" mm and preferably welded.
 - 8.3.1.7 The center line of the stilling well shall be 900 mm from the tank shell in order to minimize temperature effects from the tank shell.
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- 8.3.1.8 A vapor seal is recommended to minimize vapor emissions. A simple rubber boot clamped on the well and fixed to the roof is sufficient.
- 8.3.1.9 Stilling wells shall be equipped with all required emission control devices, which may include items such as a gasketed sliding well cover, and a pole wiper, as well as either a pole sleeve or a pole float and float wiper.
- 8.3.1.10 The stilling well hole size and placement shall be in accordance with the RTG Manufacturer specifications. At a minimum, two rows of overlapping slots or holes located on opposite sides of the pipe are required.

Commentary Note:

For most hydrocarbon applications, a double row of 1" to 1½" holes on opposite sides of the pipe, with the holes staggered on both sides with a pitch of approximately 2 ft is recommended. It is also suggested to let the holes be radial on the center of the tank (minimizing product flow through the pipe). All holes should be properly de-burred.

- 8.3.1.11 Stilling well segments shall be welded only on the outside. Inside welding slags will reflect radar signals and will have an influence on the signal to noise ratio and speed of the radar signal.
- 8.3.1.12 Prior to the installation of an RTG system onto the stilling well of upright cylindrical tank pre-installation verifications are required as detailed in API MPMS Chapter 3.1B.

8.3.2 RTG Installation on Existing Stilling Wells

Existing stilling wells are suitable for use if they meet the following criteria:

- a) The bottom lip of the stilling well should extend to within 30 cm (12 inches) of the tank bottom.
 - b) The stilling well will have one or two rows of slots or holes of about 1-inch (25 millimeters) width, on opposite sides and continuing up above the maximum oil level. Solid pipes are not acceptable for use. The total area of the slots shall not exceed 9 square feet for an 8-inch pipe.
 - c) The stilling well is vertical within 1 degree.
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- d) The stilling well has a uniform inside diameter.
- e) A stilling well shall be supported at the tank bottom or on the lowest part of the tank shell less than 1 foot from the tank bottom in accordance with the requirements of API MPMS Chapter 3.1B.
- f) The recommended diameter of the stilling well is 8 inches. Smaller size pipes are acceptable if they provide sufficient structural strength to support RTG installations; and the stilling well is wide enough to allow the operator to collect manual samples.

Commentary Note:

Using secondary stilling well inside the original stilling well for sampling has a negative influence on how representative the product sampled is compared to the average product in the tank.

If an alternate means of supporting the stilling well is used, the support will be designed to prevent vertical movement of the point of attachment. The Chairman of the Custody Measurement Standards Committee must approve this method of attachment.

9 Installation and Verification Requirements

9.1 Rated Operating Conditions

The rated operating conditions of the RTG equipment shall be verified prior to installation. The rated operating conditions are determined by:

- Minimum and maximum temperatures and densities of the liquid and the medium above the liquid.
- Minimum and maximum pressures.
- Characteristics of the liquid and of the medium above the liquid.
- Maximum and minimum level reading of the RTG.
- Environmental conditions.

9.2 Factory Verification of RTG Equipment

It shall be performed before installation of the system on the tank.

This verification includes but is not necessarily limited to the requirements identified in [SAEP-28](#), Appendix A - Procedure for the Factory Testing of RTG Level Gauges and Automatic Tank Thermometers.

9.3 Pre - Installation

Prior to the installation of an RTG system onto the stilling well of an upright cylindrical tank the following is required:

- a) Pre-installation verification is required as detailed in [34-SAMSS-321](#).
- b) Evaluation of the technical and metrological characteristics of the tank to determine if it will support custody transfer quality measurement from the installed RTG system. This shall be determined by compliance with the following general requirements, the procedures identified in [SAEP-28](#) and API MPMS Chapter 3.1B. This evaluation will include the following:
 - i) The shape, material, reinforcement, construction and assembly is such that the tank is sufficiently resistant to the atmosphere and the effects of the contained liquid and that the tank suffers no permanent deformation which may affect its capacity.
 - ii) The dipping datum point and upper reference height are constructed so that their positions remain within 2 mm at whatever the state of filling of the tank, the temperature, etc.
 - iii) The tank is stable on its foundation, which is ensured by anchoring or by an adequate period of stabilization, with the tank remaining full so that its base will not vary with time.
 - iv) The tank structure, stability, manholes, access to the gauge hatch, and the possibility of performing a manual calibration or gauging will not be impacted by the installation of the RTG system.

9.4 Initial Verification

The initial verification confirms that the installed accuracy of the RTG level and temperature equipment is appropriate for the intended service. It is performed by comparing the manual measurements against the RTG readings. The initial verification requirements are listed below:

- * Marking and Traceability (Section 11)
- * Rated Operating Conditions (Section 9.1)
- * Initial Setting of the RTG system (Section 9.5)
- * Third Party Verification of the Installation (Section 9.6)

9.5 Initial Setting of the RTG System

The initial setting of the RTG system shall be conducted according to the procedures in [SAEP-28](#) and the requirements below:

- a) The vendor shall perform a tank inspection to determine acceptability of the tanks for RTG installation prior to installation of the system.
- b) RTG verification procedure (included in [SAEP-28](#), Appendix D - Procedure for Verification of the Initial Automatic Level Gauge (RTG) Setting).
- c) RTG shall remain within the maximum permissible errors specified for systems installed on tanks.
- d) ATT verification procedure for setting the ATT system [included in [SAEP-28](#), Appendix D - Procedure for Initial Setting of the Automatic Tank Thermometer (ATT)].
- e) With the tank full of liquid, each temperature sensor shall be verified using a recently calibrated portable electronic thermometer, in accordance with API Chapter 7.

9.6 Third Party Verification of the Installation for Custody Transfer

- 9.6.1 The requirements for “Third Party Verification of the Installation for Custody/Royalty Transfer” are included in [SAEP-28](#), Appendix E.
- 9.6.2 Prior to initial setting of a new or repaired RTG System, the tank should be allowed to stand at a constant level long enough for air or vapor to be released from the tank and to the tank bottom to reach a stable position. New tanks should be filled and allowed to stand to minimize the errors cause by tank bottom settlement. The tank mixer should be turned off before setting or verification.
- 9.6.3 The initial verification will be performed when the tank is approximately half full ($\pm 10\%$), and the RTG shall be set to the average of the five manual gaugings.

9.6.4 Tolerances shall be maintained within the limits specified in the table below:

Measurement Parameter	Acceptable Tolerance
Level Measurement - Radar Tank Gauging (RTG)	
<u>Factory Calibration Prior to Installation</u>	
Level Verification	± 1 mm (1/16 inch)
Maximum level error caused by installation and operating conditions	± 3 mm (1/8 inch)
Overall Accuracy of the Installed ATG	± 4 mm (3/16 inch)
<u>Initial and Subsequent Field Verification</u>	
Level Verification	± 4 mm (3/16 inch)

9.6.5 Tank temperature will be measured at the same time the tank level is measured. The tank temperature will be representative of the tank contents in accordance with API MPMS Chapter 7. ATT setting and Portable Electronic Thermometer usage shall follow the procedures described in Appendix C and Appendix E, respectively. Level and temperature measurement must meet the tolerances listed in the table below:

Measurement Parameter	Acceptable Tolerance
Temperature Measurement - Automatic Temperature Thermometers (ATT)	
<u>Factory Calibration Prior to Installation:</u>	
Component calibration	± 0.15 °C (0.25 °F)
System calibration	± 0.25 °C (0.5 °F)
<u>Initial and Subsequent Field Verification:</u>	
Component calibration	± 0.5°C (1°F)
System calibration	± 0.5°C (1°F)
System average value comparison	± 0.5°C (1°F)
<u>Reading and Reporting:</u>	
Read and reported to the nearest	± 0.1°C or 0.1°F

9.6.6 Sealing Calibration Adjustment - RTGs used for Custody/Royalty measurement will allow facilities for sealing of the calibration adjustment to prevent unauthorized adjustment or tampering.

9.7 The final calibration will be performed by verifying the RTG reading at three random test levels in the top, middle, and bottom thirds of the gauge travel using referee manual gaugings. The following conditions shall be met during the verification:

- a) The referee gaugings shall be either five consecutive manual gauge readings within an error band of 3 mm (3/16 inch) or three consecutive gaugings within 1 mm (1/16 inch). Failure of either group to check within these limits is cause for repeating the calibration.
- b) The average manual levels and the average RTG levels shall be compared at each of the three test levels. If the average manual level and the average RTG level agree within 4 mm (3/16 inch) at all three levels, the RTG shall be considered properly calibrated for Custody/Royalty Transfer level measurement and the data shall be submitted to CMU for final approval.
- c) Responsibilities and procedures for Third Party Verification of the Installation for Custody/Royalty Transfer are included in [SAEP-28](#), Appendix F.

9.8 Subsequent Field Verification

A regular verification program consisting of the following elements is required for Custody/Royalty Transfer RTGs as identified below:

- a) All essential components of the RTG installation shall be checked as recommended by the manufacturer's instructions.
 - b) Initially, each RTG will be inspected and its level measurement shall be verified at one levels of product each month, using a valid calibrated innage gauging tape.
 - c) If operating experience confirms stable performance within the calibration tolerance, the verification schedule can be extended to once per quarter.
 - d) The ATG shall be inspected and examined to establish that it is in correct working order.
 - e) Every quarter, when the RTG level reading is being verified, at least two non-adjacent ATT temperature sensors, under the liquid level, shall be verified.
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9.9 Obtaining CMU Approval

CMU approval is required before a tank RTG system can be used for Custody/Royalty Transfer Measurement. The following documentation shall be submitted to CMU to obtain this approval:

- a) New certified tank capacity tables reflecting revised reference height with field data and calculation report.
- b) RTG calibration documentation including field notes.
- c) Initial and final test verification data for RTG level and ATT measurement.
- d) Subsequent RTG level and ATT verification datasheets for 3 months.
- e) Certification documentation for gauge tape and portable electronic thermometer.

10 Tank Management System

The Tank Management System shall conform to requirements stated in API Chapter 12.1.1 as specified in [34-SAMSS-321](#).

11 Testing and Inspection

- 11.1 RTG system components shall undergo a Factory calibration and Factory Acceptance Test (FAT) at the Vendor's facility. This test shall ensure the system meets all functional and operational requirements including those specified in [SAEP-28](#). The Vendor shall provide simulators that perform the functions of any missing components.
- 11.2 A verification test (SAT) shall be performed after the system is permanently installed at the field location per [SAEP-28](#). The fully integrated RTG system shall be tested on-site to demonstrate acceptable performance.

12 Shipping Requirements

All necessary repairs, replacements or modifications to hardware, firmware, and software, shall be completed at the FAT by the Vendor prior to shipment. The Vendor shall be responsible for ensuring the equipment is properly prepared for shipment, including, but not limited to, the requirements specified hereafter.

12.1 Electronic and Electrical Equipment

- 12.1.1 Power Supply and Wiring - Instrument power supply, signal and control wiring shall be in accordance with [SAES-P-103](#), "UPS and DCS,"

[SAES-P-104](#), “Wiring Methods and Materials” and [SAES-J-902](#), “Electrical Systems for Instrumentation.” RTG and ATT installations shall comply with Saudi Aramco Library Drawing DC 950043 “Electrical Connections for Field Mounted Instruments.”

12.1.2 For Intrinsically Safe (IS) systems, the design and installation shall be as per in [SAES-J-903](#), “Intrinsically Safe Systems.” In addition, a local power disconnect switch, which is easily accessible to an Operator shall be provided at the gauge head. IS systems shall only be considered in exceptional cases and will require approval by the Manager, Process & Control Systems Department.

12.1.3 The Vendor shall determine if electronics and instruments are susceptible to damage from shock, weather or extremes of temperature during shipment. If required, such items shall be removed after the functional test and shipped separately. Electronic equipment shall be prepared and protected for shipment in accordance with the manufacturer's recommendations. As a minimum, the equipment shall be fitted with a vapor phase inhibitor emitter (CORTEC VpCI-101, VpCI-105, VpCI-110 or equivalent). Electrical boxes shall be fitted with vapor phase inhibitor emitters (CORTEC VpCI-101, VpCI-105, VpCI-110 or equivalent).

12.2 Marking and Traceability

12.2.1 All equipment and internals being shipped shall be braced and temporary supports shall be provided, if required, to prevent damage during shipment. Equipment shall be marked with water-soluble materials that will not attack or damage the equipment at either ambient or operating temperatures. Marking materials shall be free of lead, sulfur, zinc, cadmium, mercury, chlorine and all other halogens. Markings for export shall conform to the requirements specified on the purchase order.

12.2.2 RTG level and temperature equipment markings shall be legibly and clearly marked. The descriptive markings shall be indelible and of a size, shape and clarity allowing easy reading under operating conditions. They shall be grouped together in a clearly visible place on the level gauge itself or on a data plate fixed to it. The RTG System shall be labelled with the following information:

- Name of the manufacturer or trademark.
 - Serial number and year of manufacture.
 - Accuracy class designation.
 - Ranges defining the rated operating conditions.
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13 Documentation

- 13.1 Project drawings shall conform to the requirements of [SAES-J-004](#) and [SAES-J-005](#).
- 13.2 Factory drawings, specifications and test procedures shall be reviewed by CMU, SAPMT and Proponent as necessary.
- 13.3 The vendor shall provide calibration test results, tank survey report findings and supporting field documentation and on-site calibration results as part of the installation documentation.
- 13.4 Documentation for RTG system equipment and test certificates shall be furnished in accordance with the purchase order(s) and relevant material specifications.

Revision Summary

6 September 2011	New Saudi Aramco Engineering Standard.
29 September 2013	Editorial revision to change the primary contact persons.